



Rapid Environmental Assessment Meeting the Needs of Sea Power 21

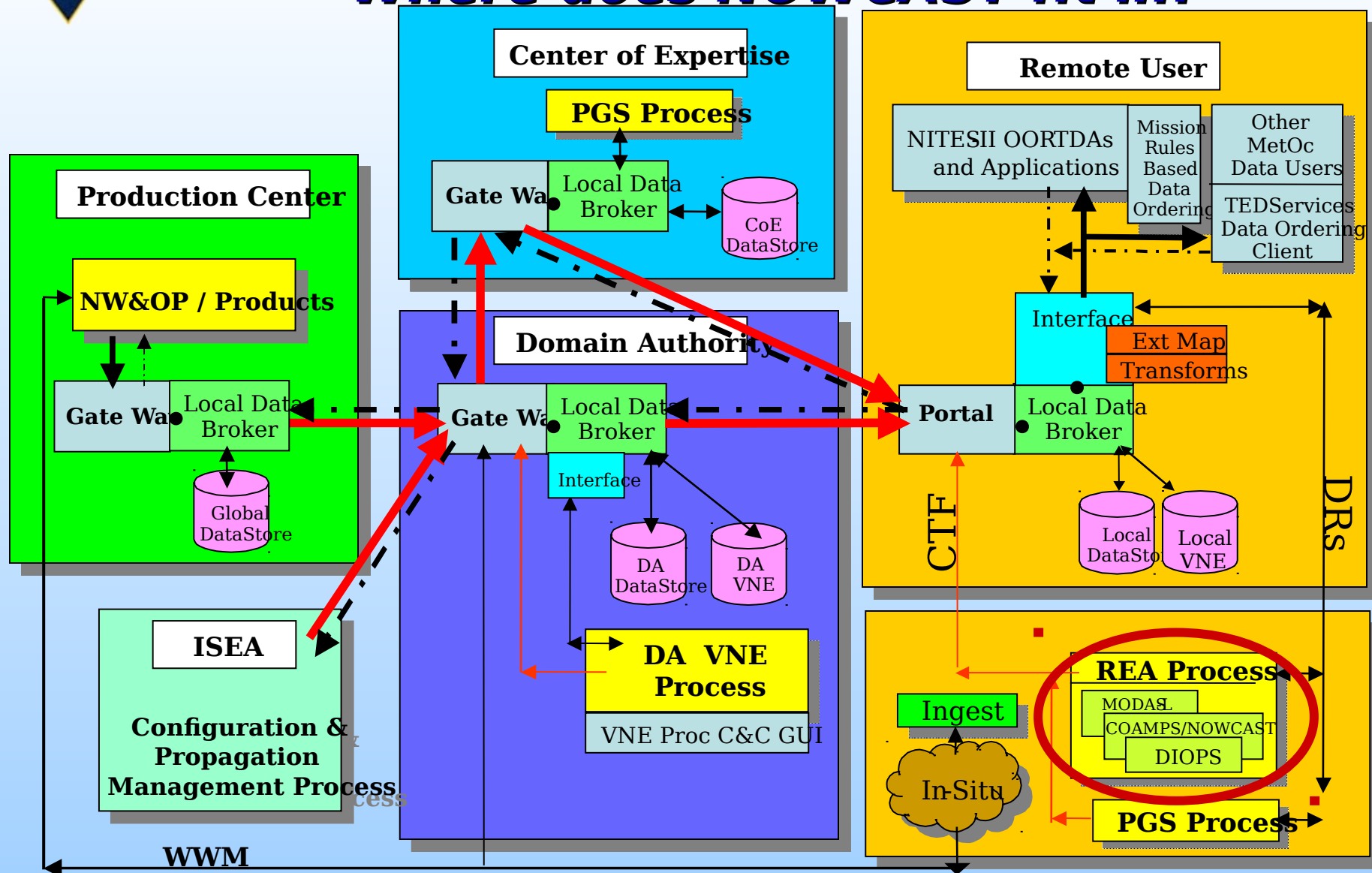
**John Cook
Naval Research Laboratory
Marine Meteorology Division
Monterey, CA**

**cook@nrlmry.navy.mil
<http://www.nrlmry.navy.mil>**



TEDServices - High Level Architecture

Where does NOWCAST fit in?



et - Connecting warriors, weapons, sensors, networks, decision aids and support



Navy Transformation Roadmap

Power and Access...From the Sea

The US Navy and Marine Corps Corporate Laboratory

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Sea Strike

Sea Shield

Sea Basing

FORCEnet

theater operations of a JTF Commander from a mobile, self-deploying sovereign command center at sea, potentially exploiting the MPF(F) hull as a host.

- Real-time Meteorological and Oceanographic Battlespace Characterization for gaining asymmetric advantage by collecting, processing, and exploiting environmental data on-scene in synchronization with the battle forces. This will employ UUVs, UAVs, and USVs, satellite downlink, tactical radar, and high capacity computing capability.
- A web-enabled Navy allowing collaborative planning and execution, facilitated by the Navy Marine Corp Intranet (NMCI) ashore and IT-21 shipboard networks that provide satellite access for shipboard users to ashore classified and unclassified



NOWCAST Helps Meet Sea Power 21 Transformational Goals

The US Navy and Marine Corps Corporate Laboratory

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	Sea Strike	Sea Shield	Sea Basing
1. Chemical/Biological Defense		✓	✓
2. Time Sensitive Strike	✓		
3. Extended Fire Support			✓
4. Enhanced Battlespace Situational Awareness	✓	✓	✓
5. Information Superiority	✓	✓	✓
6. 4D Cube	✓	✓	✓



Weapon and Flight Hour Costs

Weapon Costs

Costs per Flight Hour

MAVERICK -----	\$251,532
HELLFIRE -----	\$433,023
HARM -----	
\$323,000	
HARPOON -----	
\$495,000	
SPARROW -----	\$170,376
AMRAAM -----	
\$290,666	
SLAM ER -----	
\$874,000	
JSOW -----	
\$212,558	
JDAM -----	\$
31,932	
GBU -----	\$
70,000	

FA-18C-----	\$
4,135	
FA-18E-----	\$ 2,597
F-14A-----	\$
8,162	
E-2C-----	\$
5,138	
EA-6B-----	\$
5,237	
S-3B-----	\$
4,095	
SH-60B-----	\$
1,971	
B-2C-----	\$





NPS Thesis: The Role of Weather in Major Naval Aviation Mishaps

6

The US Navy and Marine Corps Corporate Laboratory

Key Findings of LCDR Alex Cantu, USN, 2001:

- **Weather related mishaps caused an average of 11 deaths and \$74 million in damage each year during FY 90-98**
- **Weather was a factor in:**
 - 12% of all (395) Class A mishaps
 - 19% of all (235) human factors mishaps
 - 41% of all controlled flight into terrain mishaps
 - 40% of tactical aircraft wave-off mishaps
 - 41% of adverse physiological state pilot error mishaps
 - 36% of embarked-night pilot error mishaps
 - 34% of helicopter pilot error mishaps
 - 66% of helicopter landing pilot error mishaps
- **Visibility factors were involved in most (54%) of the weather related mishaps**
- **Most (56%) of weather related mishaps were preventable with a perfect**

CNO Guidance for 2003 - Achieving Sea Power
21

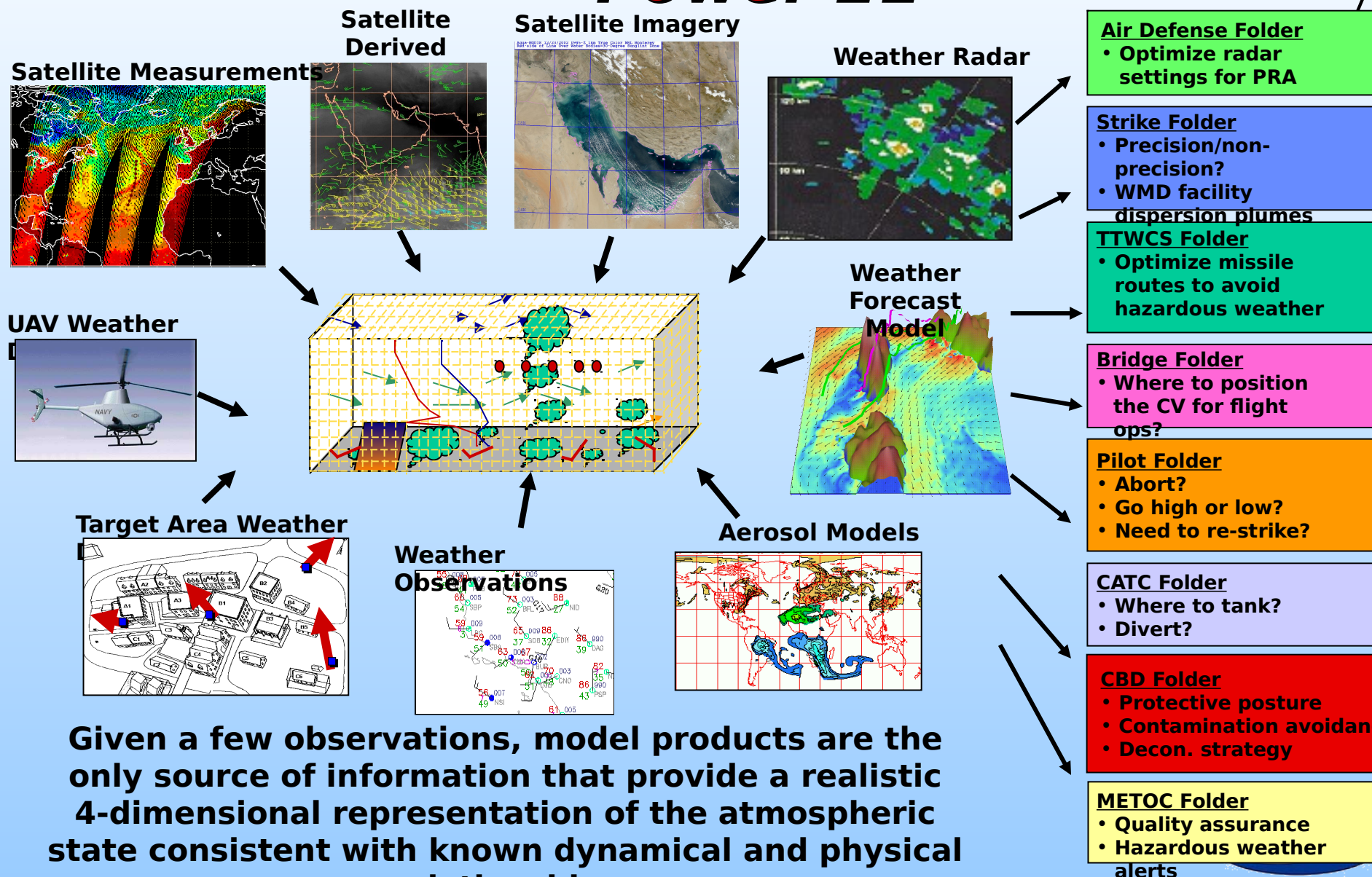
**Continue to improve fleet readiness by
reducing Class "A" mishaps by 25% over FY02
numbers**





Populating the 4D Cube for Sea Power 21

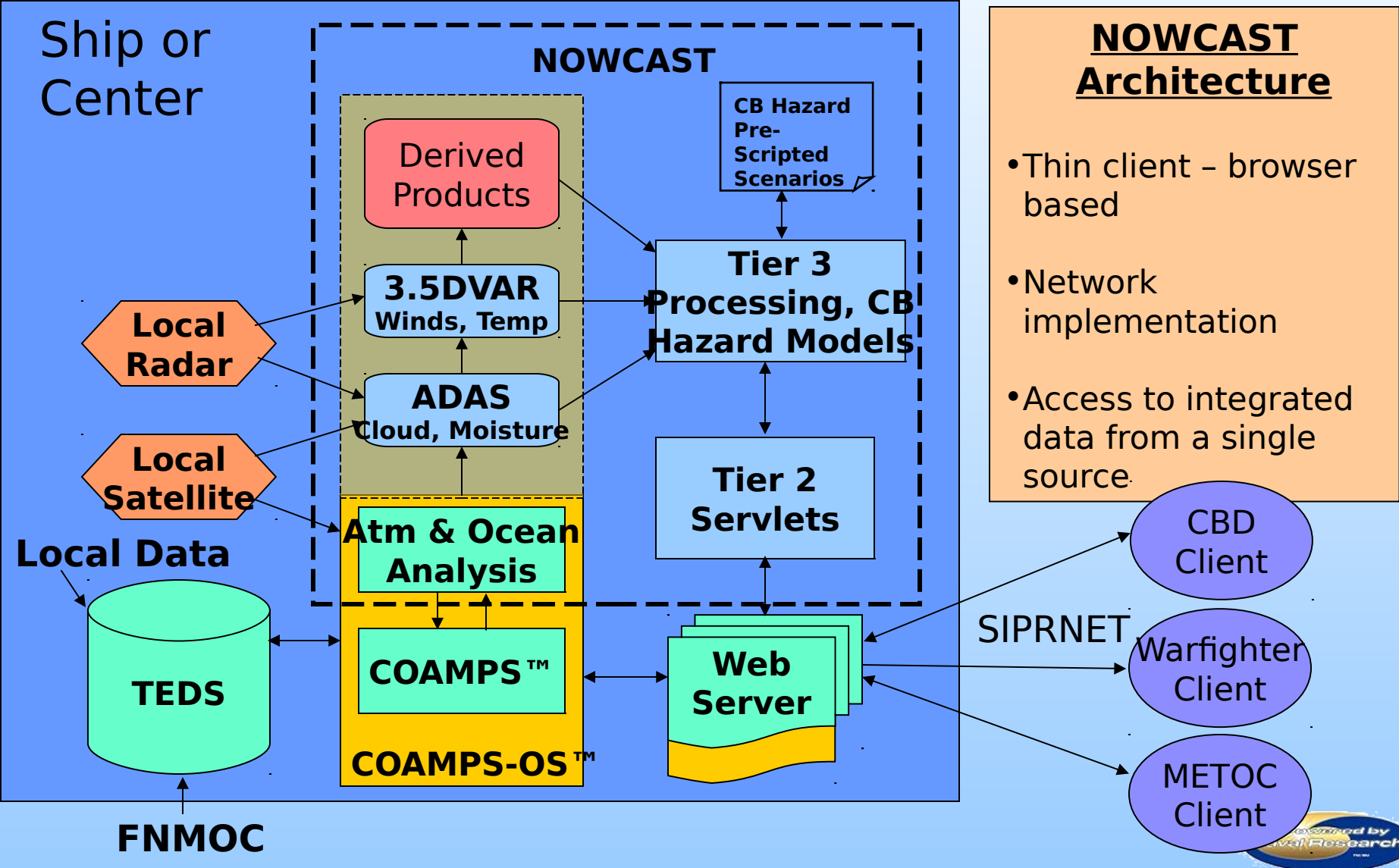
The US Navy and Marine Corps Corporate Laboratory



Given a few observations, model products are the only source of information that provide a realistic 4-dimensional representation of the atmospheric state consistent with known dynamical and physical



Architecture



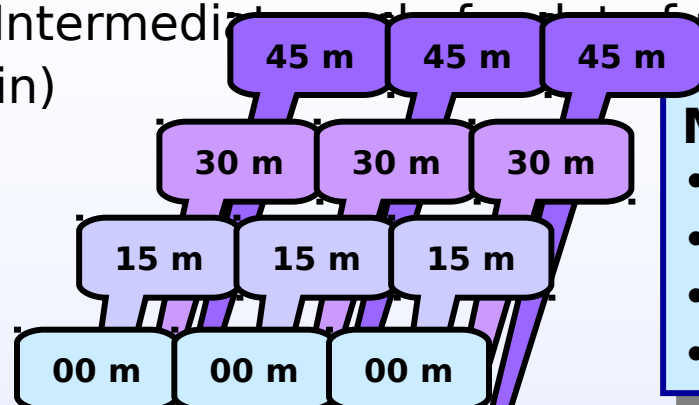


NOWCAST Time Levels

Getting Inside the Warfighter's Decision Loop

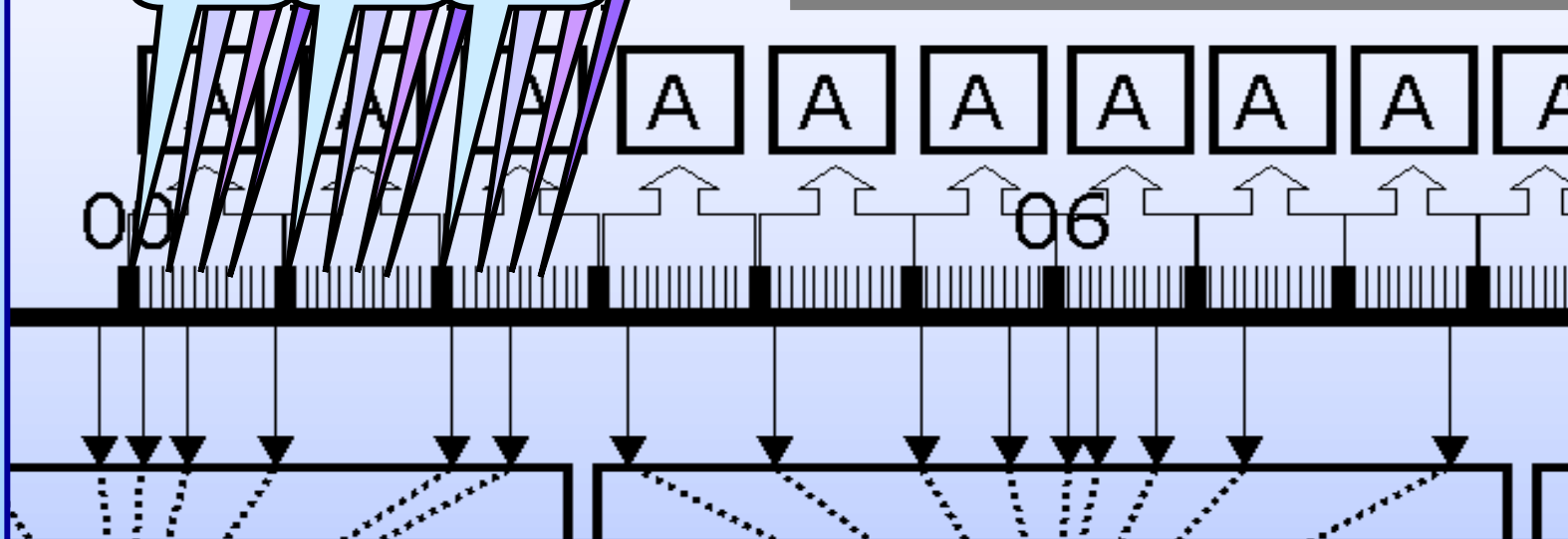
9

- Use hourly atmospheric analyses as background conditions
- Intermediate fused parameters (~15 min)



Multiple time levels

- 6 or 12 hourly NWP data assimilation cycle
- Hourly analysis cycle
- 15 minute data fusion process
- 5 minute observation data rate





NOWCAST User Interface

The US Navy and Marine Corps Corporate Laboratory

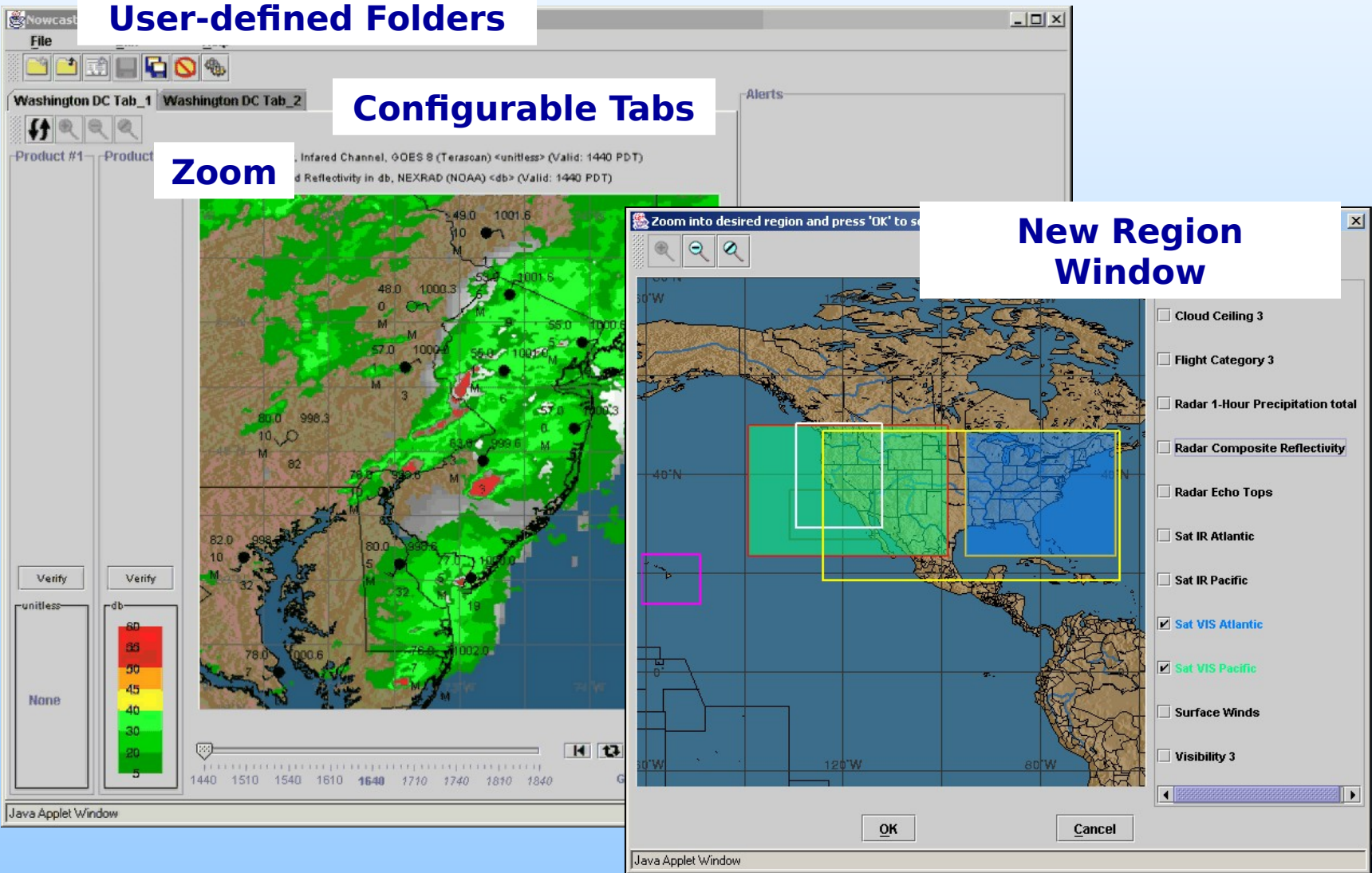
Automatic Updates

User-defined Folders

Configurable Tabs

Zoom

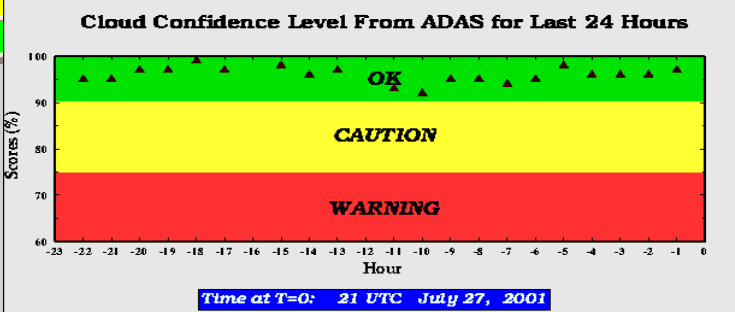
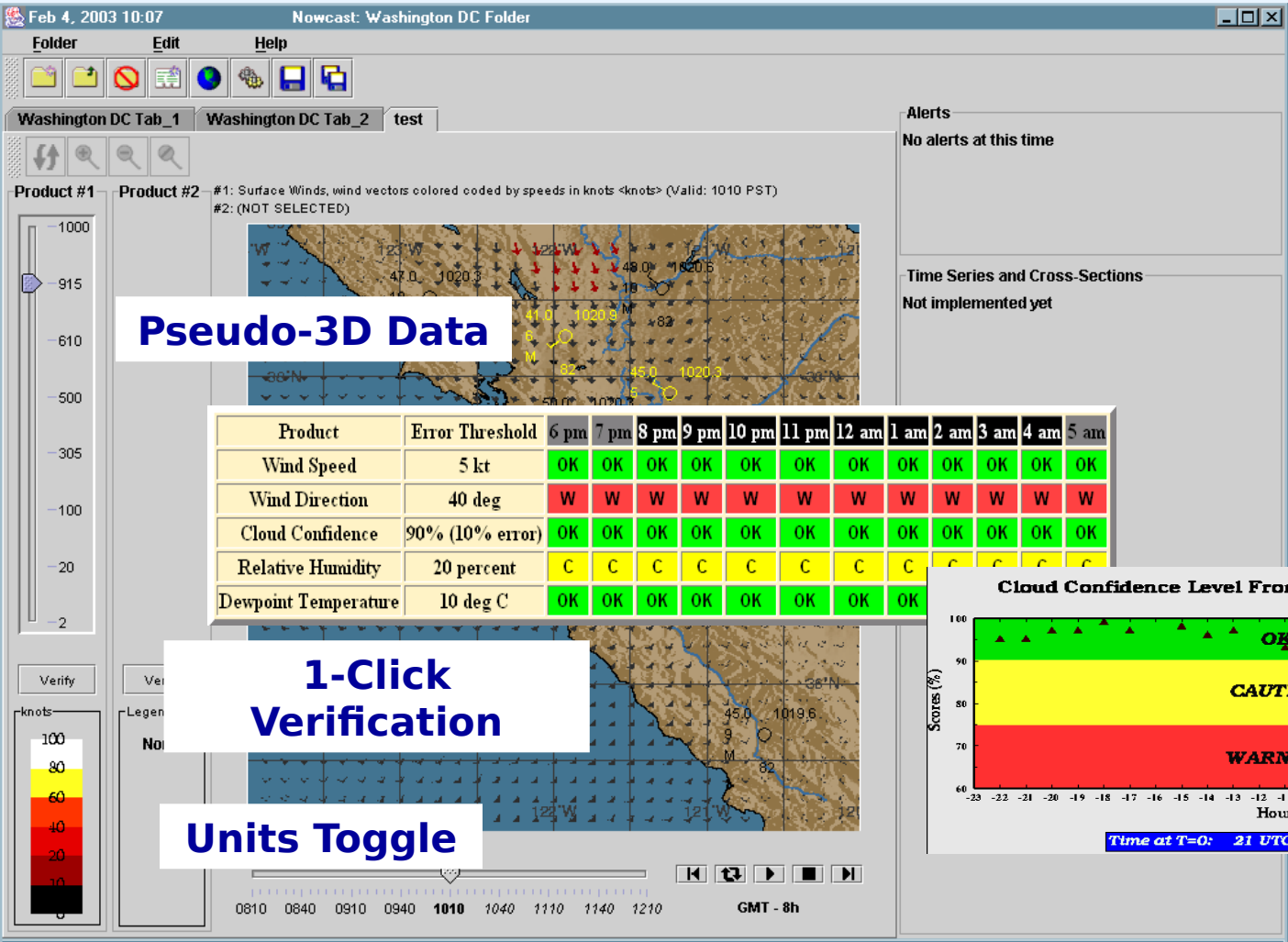
New Region Window





NOWCAST Web-Based Applet Interface Features

The US Navy and Marine Corps Corporate Laboratory

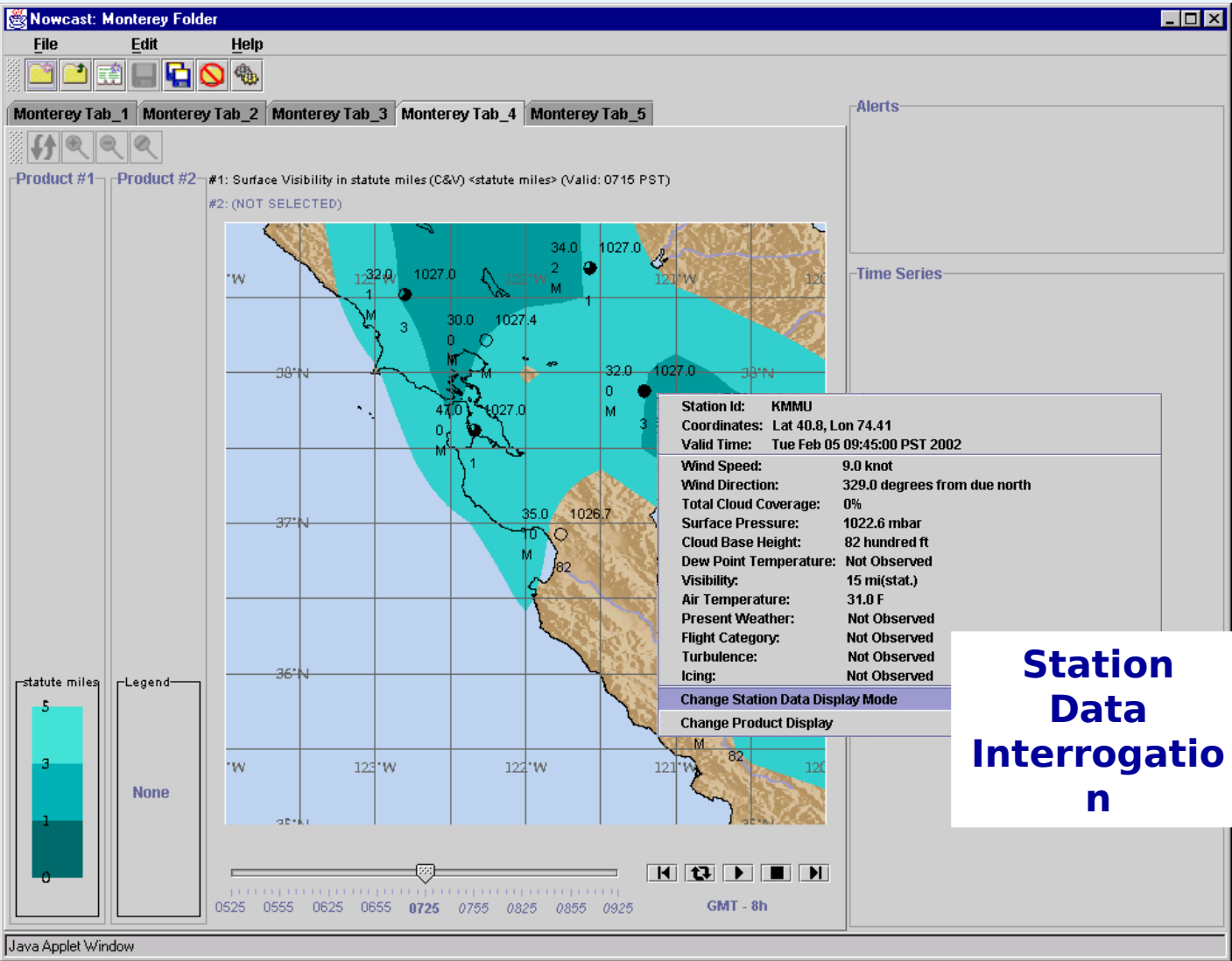




NCAR C&V - Visibility Monterey Area

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The US Navy and Marine Corps Corporate Laboratory



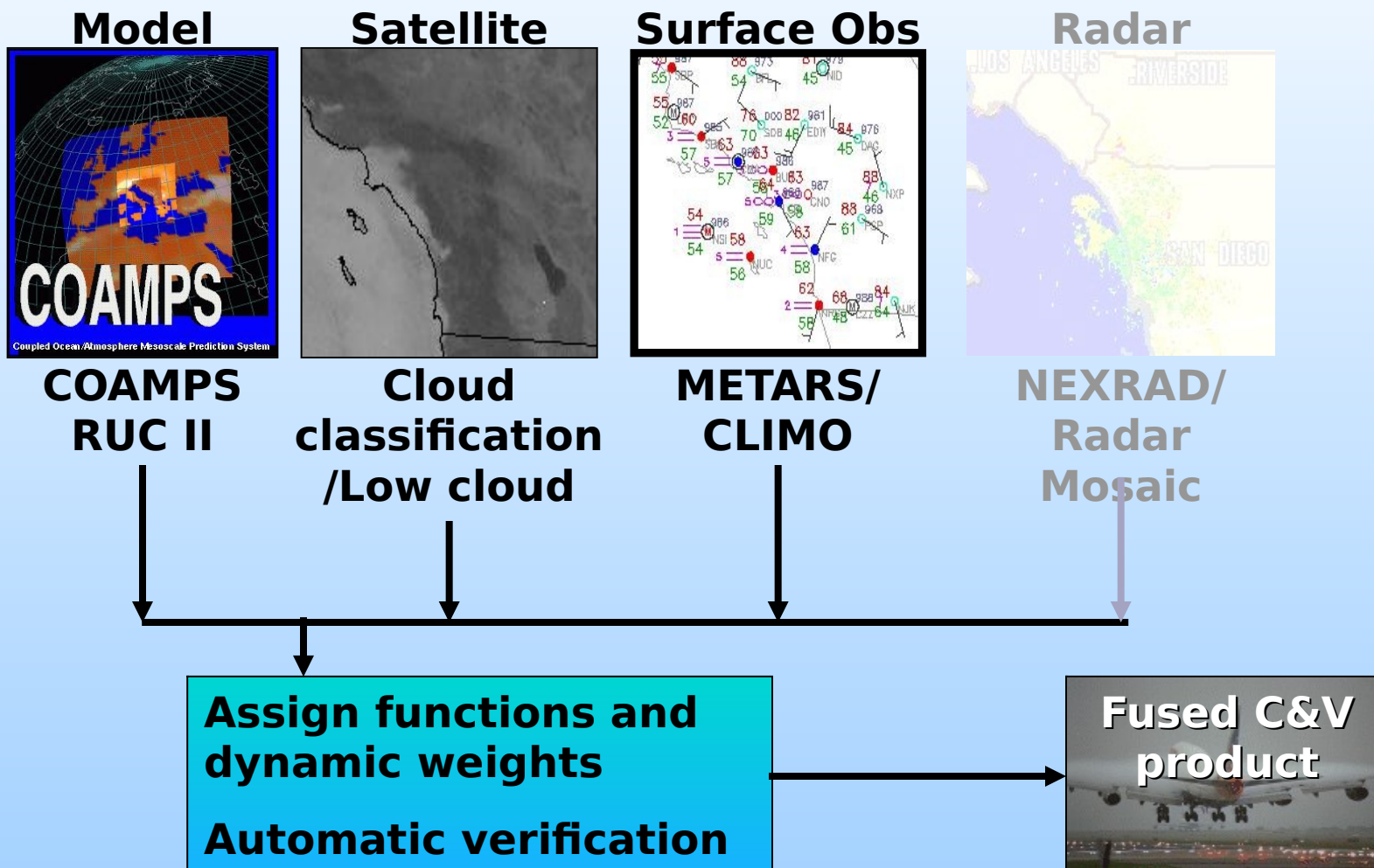
**Station
Data
Interrogation**





NCAR Fuzzy Logic Ceiling & Visibility Product

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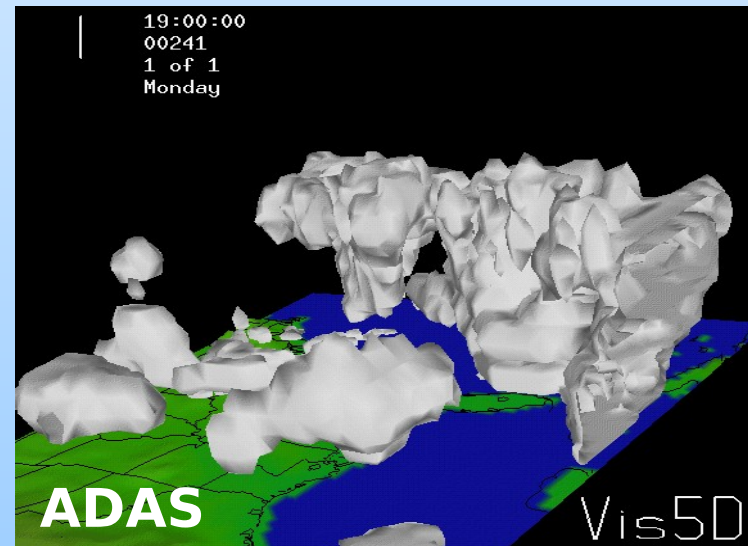
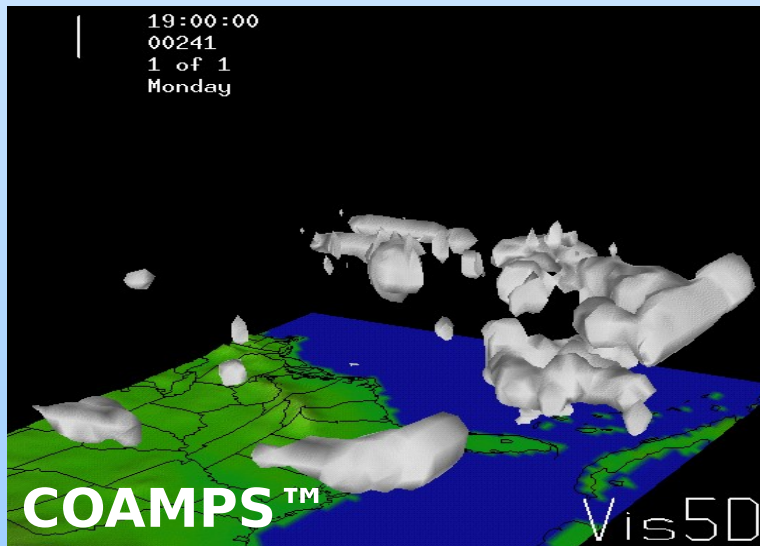
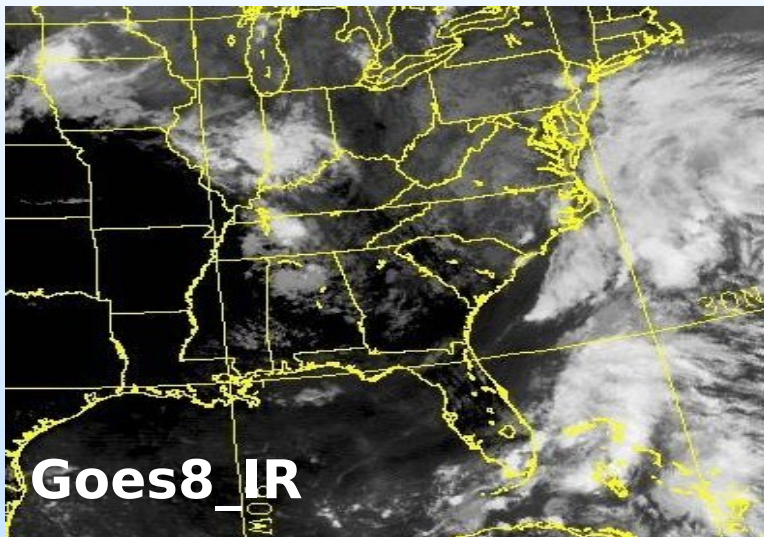




ADAS Cloud Analysis System

The US Navy and Marine Corps Corporate Laboratory

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19Z 28 August 2000



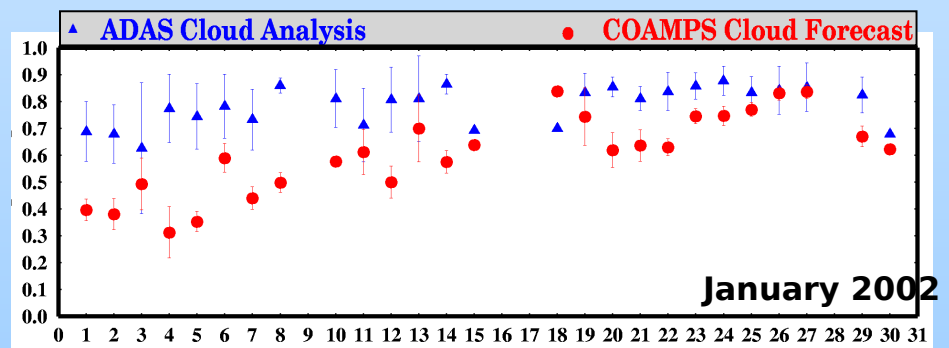
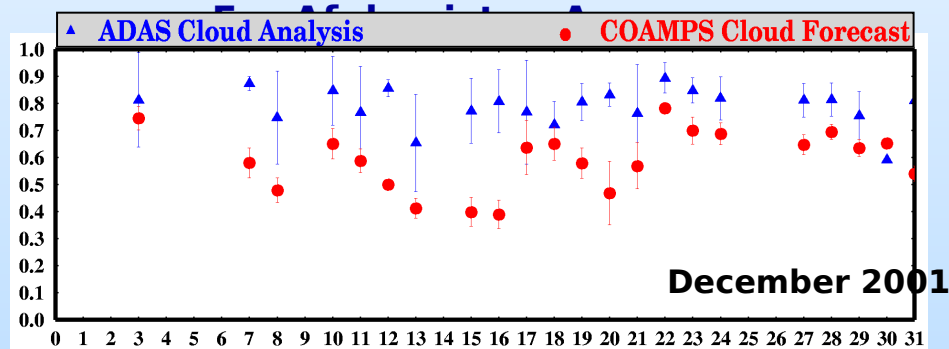


ADAS Automatic Verification System

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- A system developed for product quality assurance
- Runs hourly right after ADAS
- Verify 3D clouds against satellite and surface observations
- Calculates statistic scores of cloud confidence level, cloud top temperature correlation, equitable threat score of cloud location, and cloud base RMS errors
- Calculates daily-mean scores and standard deviation from hourly scores for a period of a month

Daily Mean Cloud Top Temperature Correlation and Standard Deviation verified against MeteoSat-5 measured Cloud Brightness Temperatures

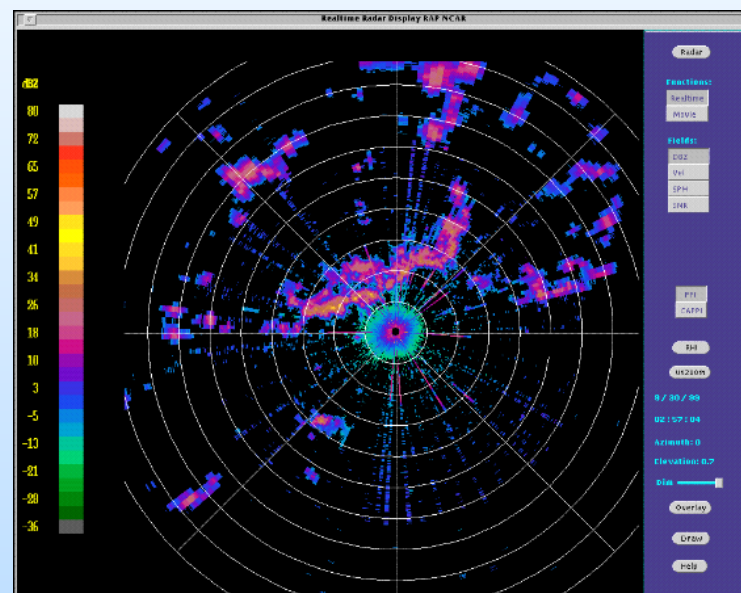




Radar Systems on Ships and at Forward-Deployed Locations

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- ❑ SPY-1 radar in the Aegis weapon system situated on DDG & CG
 - **Tactical Environmental Processor (TEP) re-processes the data from SPY-1 and makes the data comparable to NEXRAD data**
- ❑ SPS-48 Air Traffic Control radar situated on all CVN
 - **Data tapping system is under development at SPAWAR for retrieving and processing weather data**
- ❑ MetMF(R) US Marine Corps Meteorological Mobile Facility (Replacement) includes an Enterprise Doppler radar
 - **MetMF(R) provides a deployable weather office for Marine Corps Expeditionary Operations**



TEP Data from USS O'KANE located off Wallops Is.



Supplemental Weather Radar (SWR) (US Navy Shore Sites)

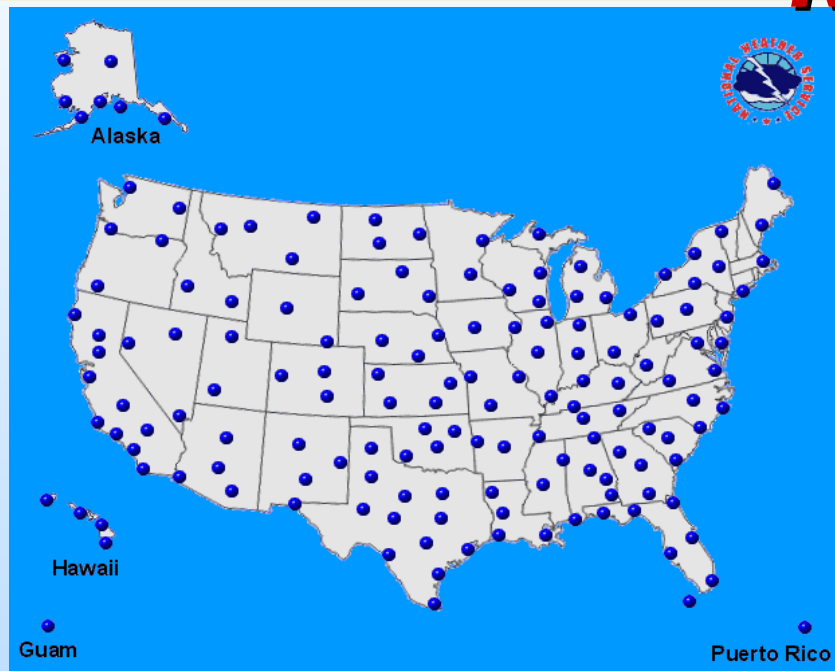
DoD is rich in potential weather radar data sources. But the data have not been used in battlespace environmental characterization yet.



Radar Data Applications to NOWCAST

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154 NEXRAD Level III Stations

- Composite & Base Reflectivity
- Echo Tops
- Base Radial Velocity
- 1 Hr Precipitation Total
- VAD Wind Profiles

**490 MB (compressed) per day
Mosaics and individual station
plots created every 10 min**

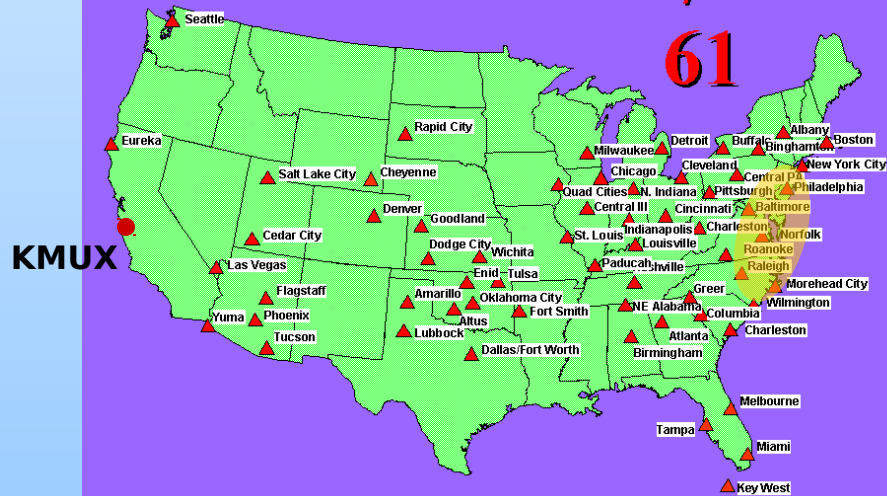
5 of 61 NEXRAD Level II

Stations

- Radial Velocity
- Reflectivity
- Spectral Width
- Echo Tracking

**600 MB (compressed) per day
Products every 6 min (precip
mode) or 10 min (clear air
mode)**

**Radars Now Delivering Real Time
Level II Data to NCDC/OU**

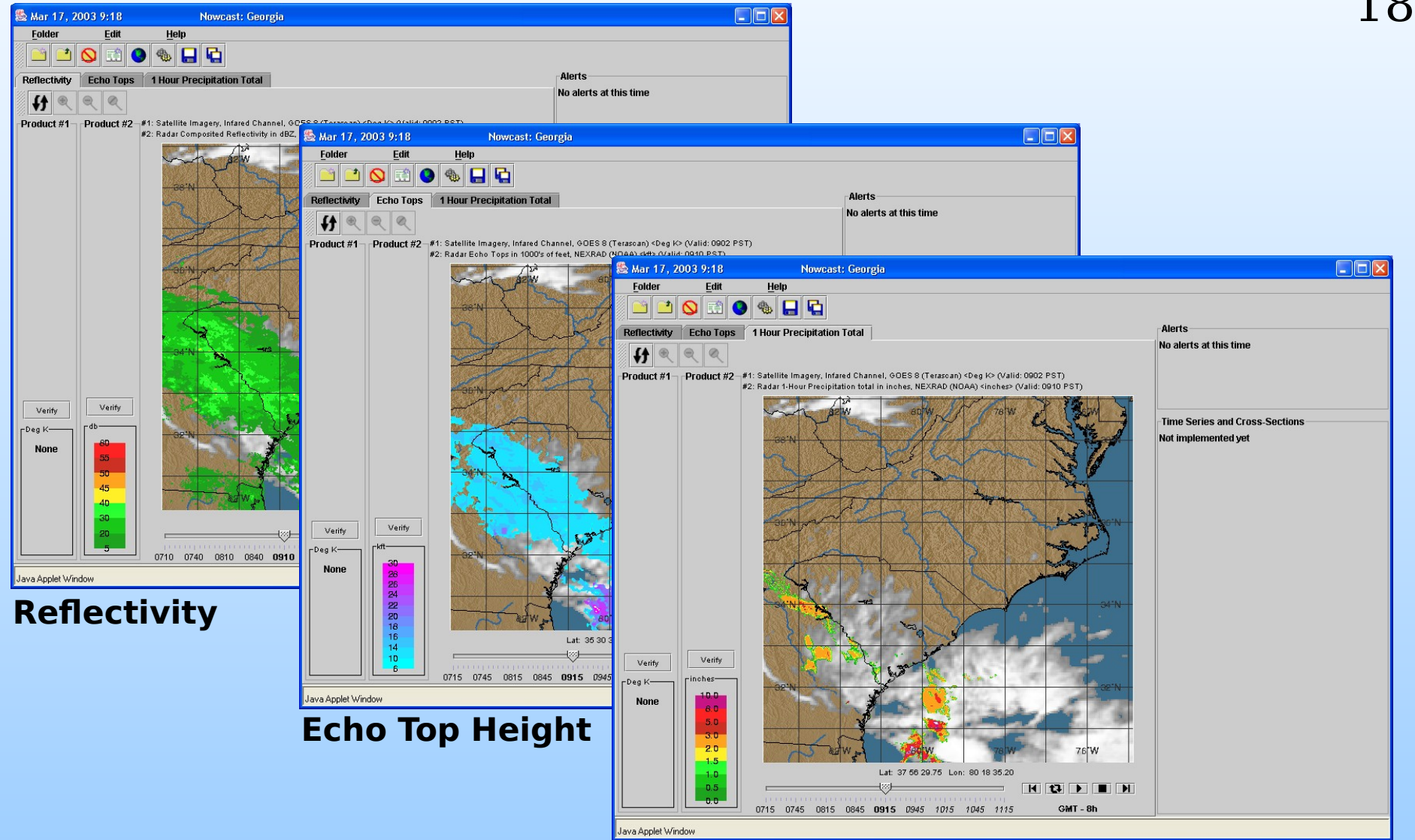




Radar Data Applications in NOWCAST

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Reflectivity

Echo Top Height

1 Hr Precipitation
Total



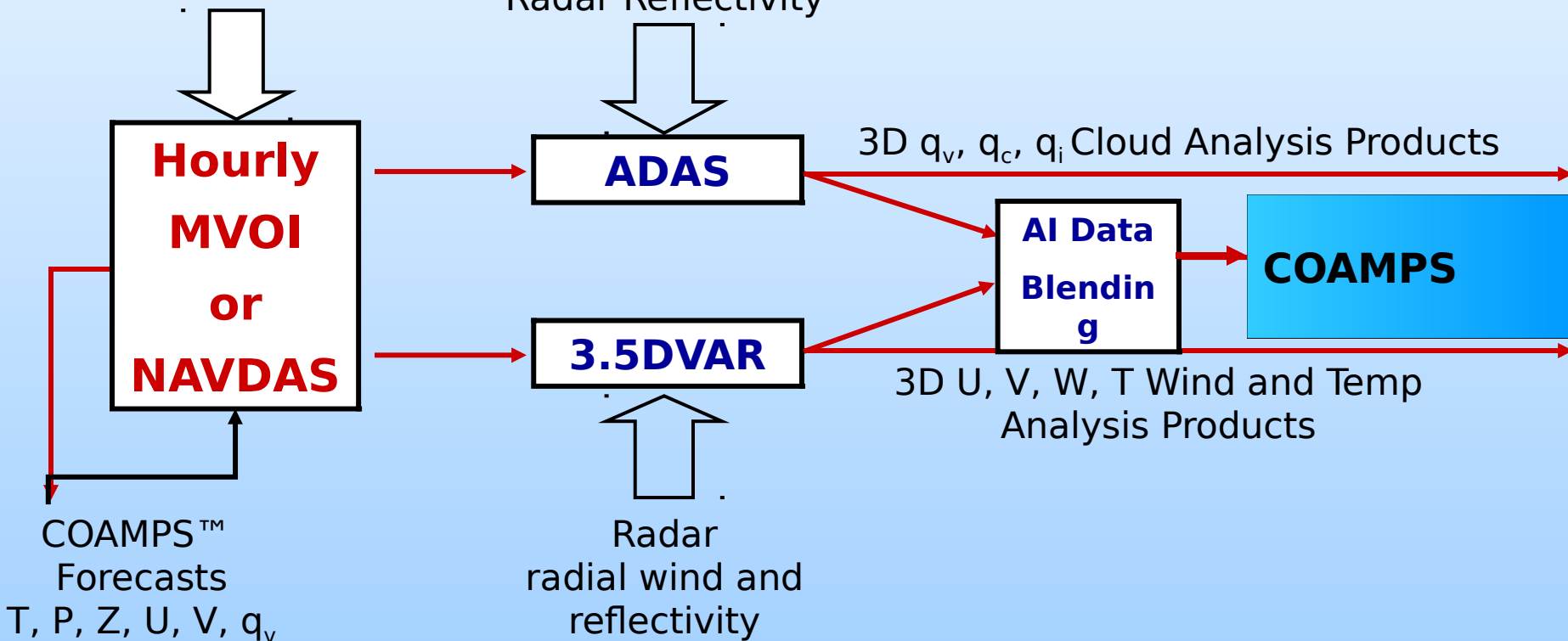


Analysis Procedure

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Conventional
And
Remotely Sensed
Observations

Satellite Data
and
Radar Reflectivity

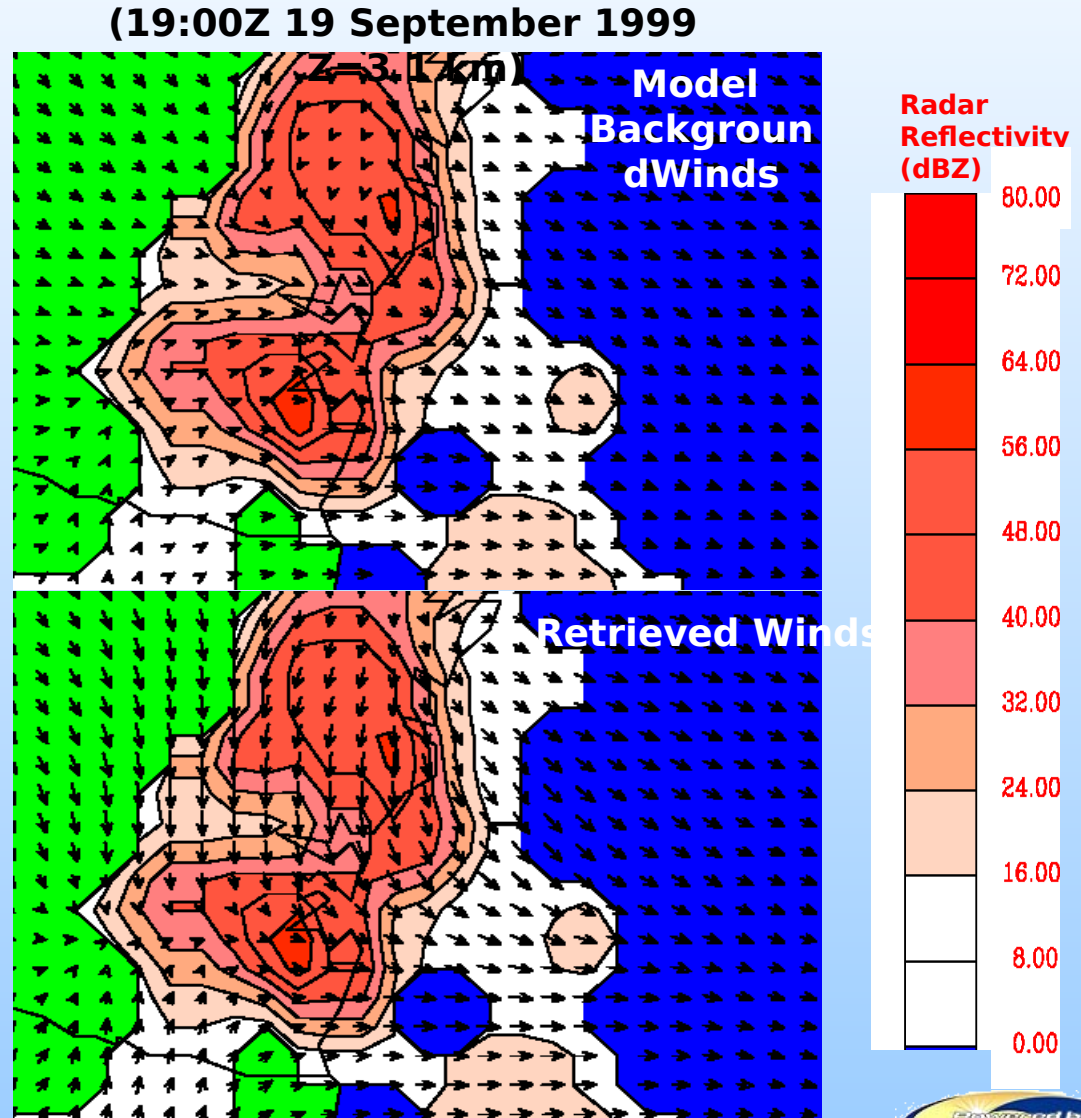




Single Radar (KJAX) Horizontal Wind Retrieval using 3.5DVAR

20

- Example of fusion of radar wind data from a single radar (KJAX) using 3.5DVAR technique for a squall line along the east coast of Florida with strong lower level convergence
- Model background predicted smooth winds with very weak convergence
- Retrieved winds show significantly enhanced wind speed and low-level convergence, much more consistent with thunderstorm dynamics
- Technique tested with up to three radars
- Limited to hourly temporal frequency of the model





Single Radar (KJAX) Horizontal Wind Retrieval using 3.5DVAR

The US Navy and Marine Corps Corporate Laboratory

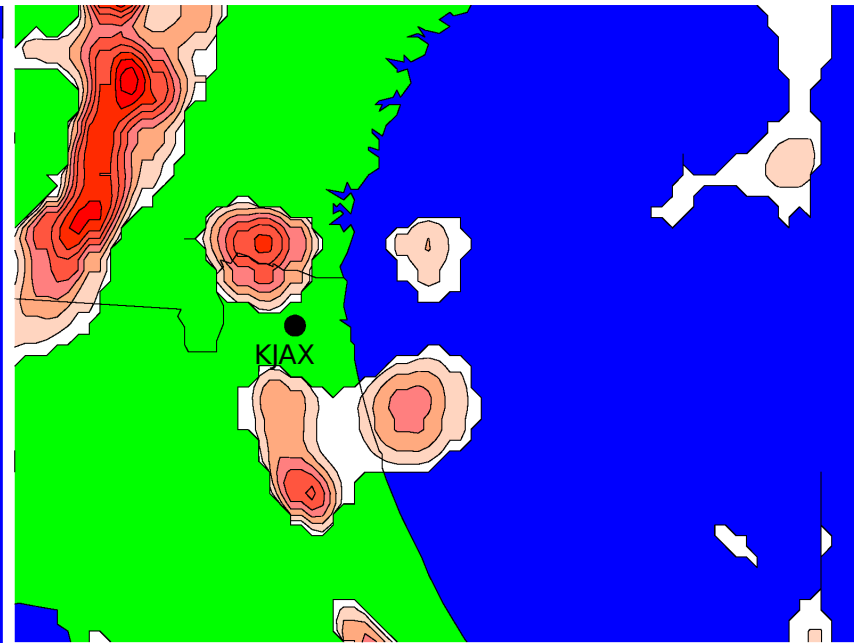
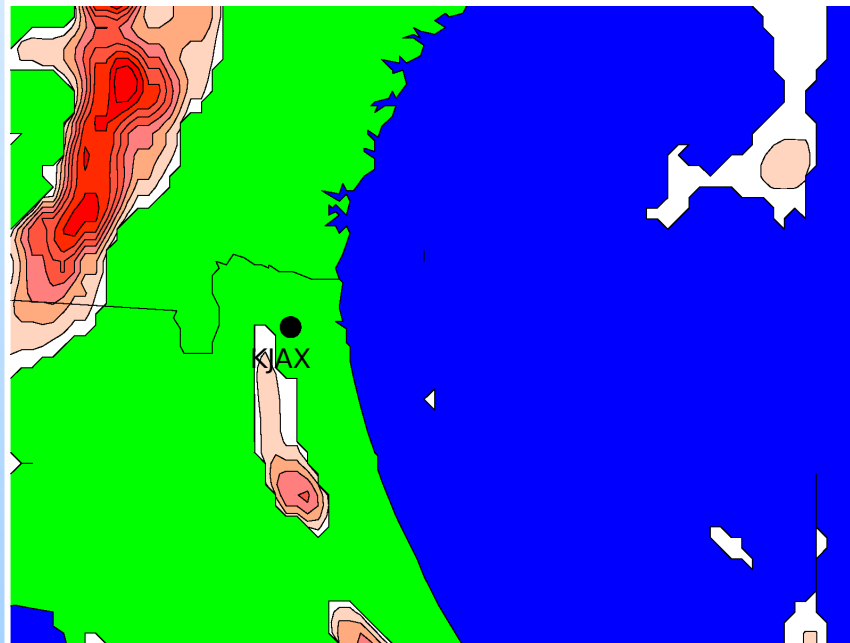
21

19:00Z 19 September 1999

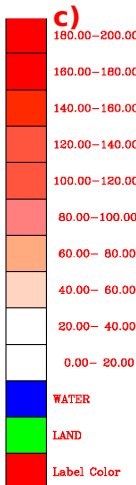
Z=3.1 km

Model Forecast

Retrieved



Upward
Wind
Speed
(mm/se
c)



WATER

LAND

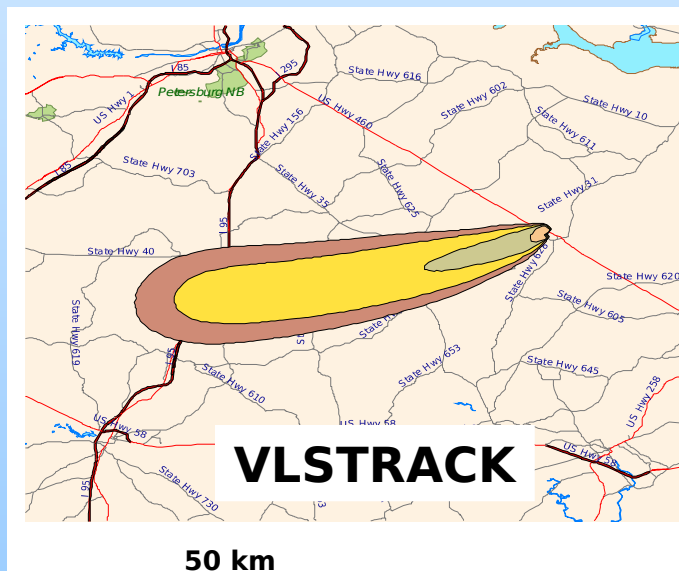
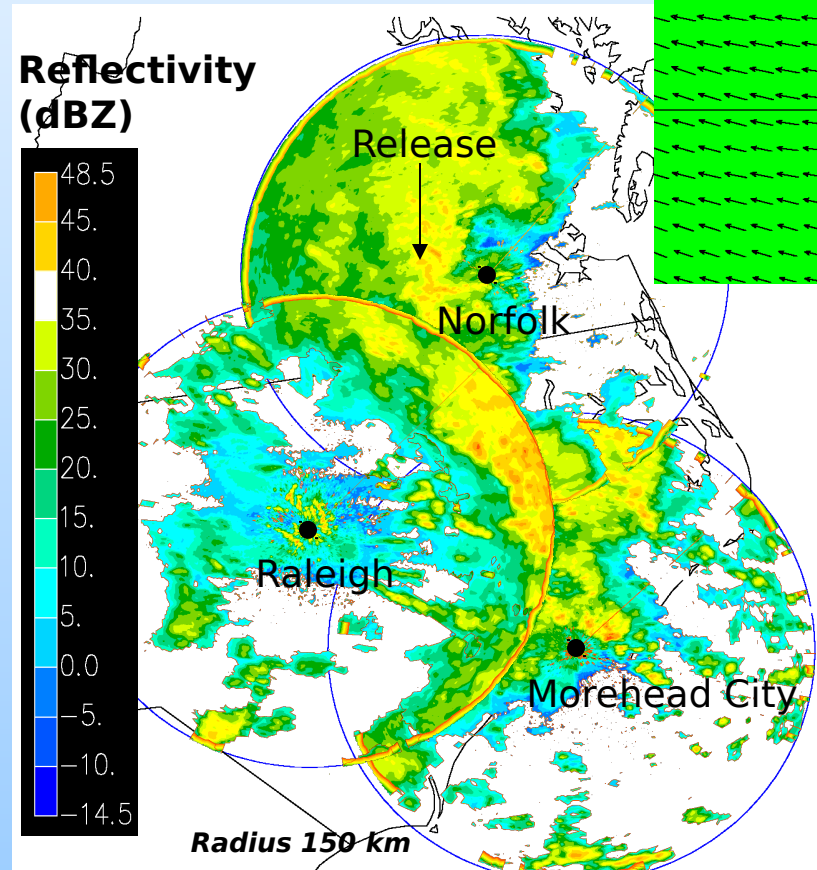
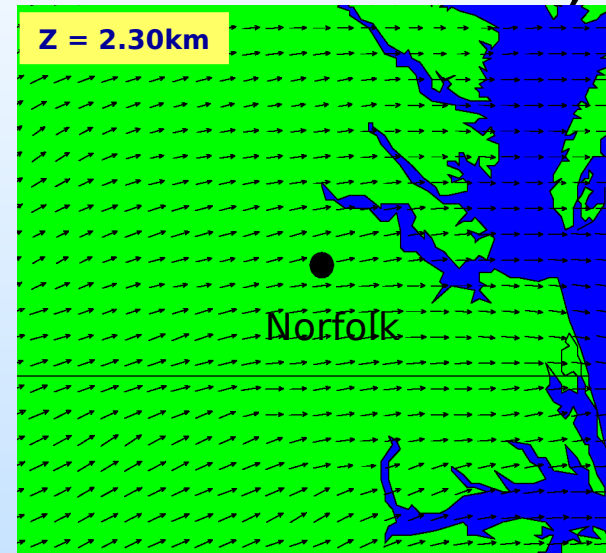
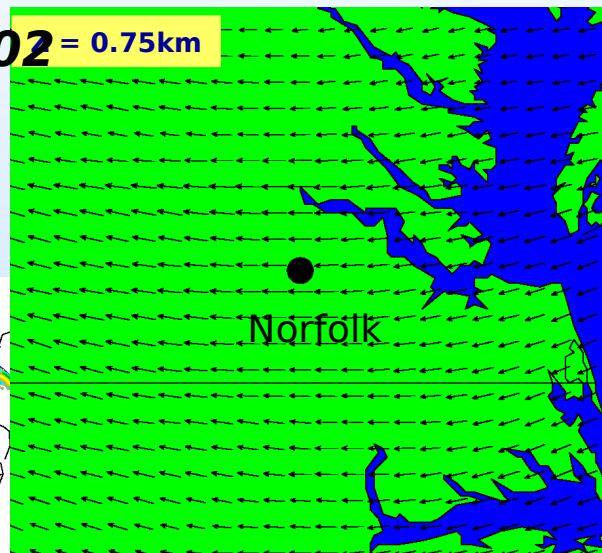
Label Color



3.5DVAR Wind Retrieval using Multiple Doppler Radars

The US Navy and Marine Corps Corporate Laboratory

16:08Z 29 October 2002 = 0.75km



Surface
release

2 kg bio
agent, 2 km
line

1.5 hr
simulation

Dosage
contours





NOAA Multiple Doppler Variational Wind Analysis

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**NEXRADs at
Morehead
City, NC &
Wakefield, VA**

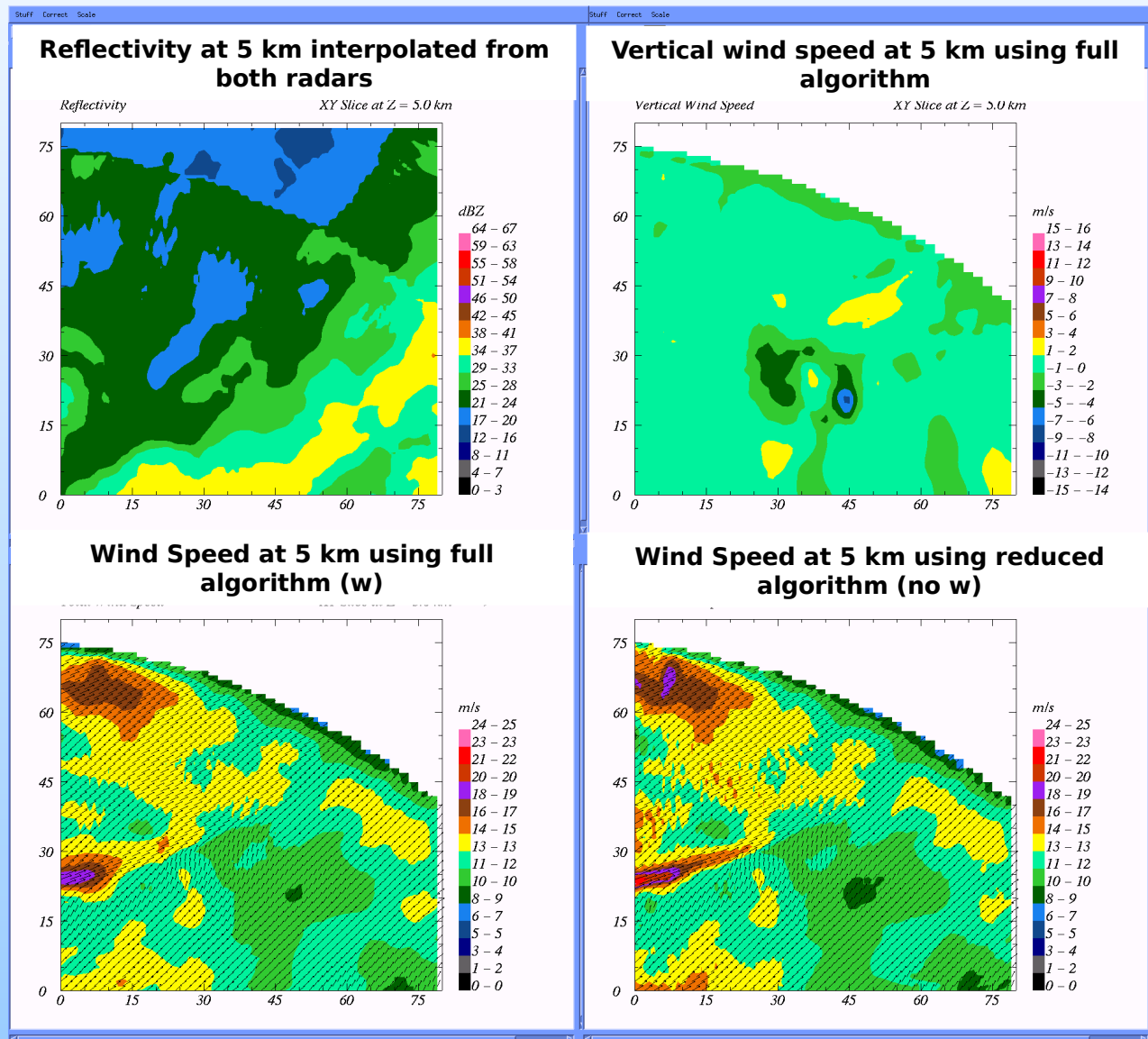
**80 X 80 grid
1 km spacing**

**Full
algorithm: 13
min**

**Reduced
algorithm: 5
sec**

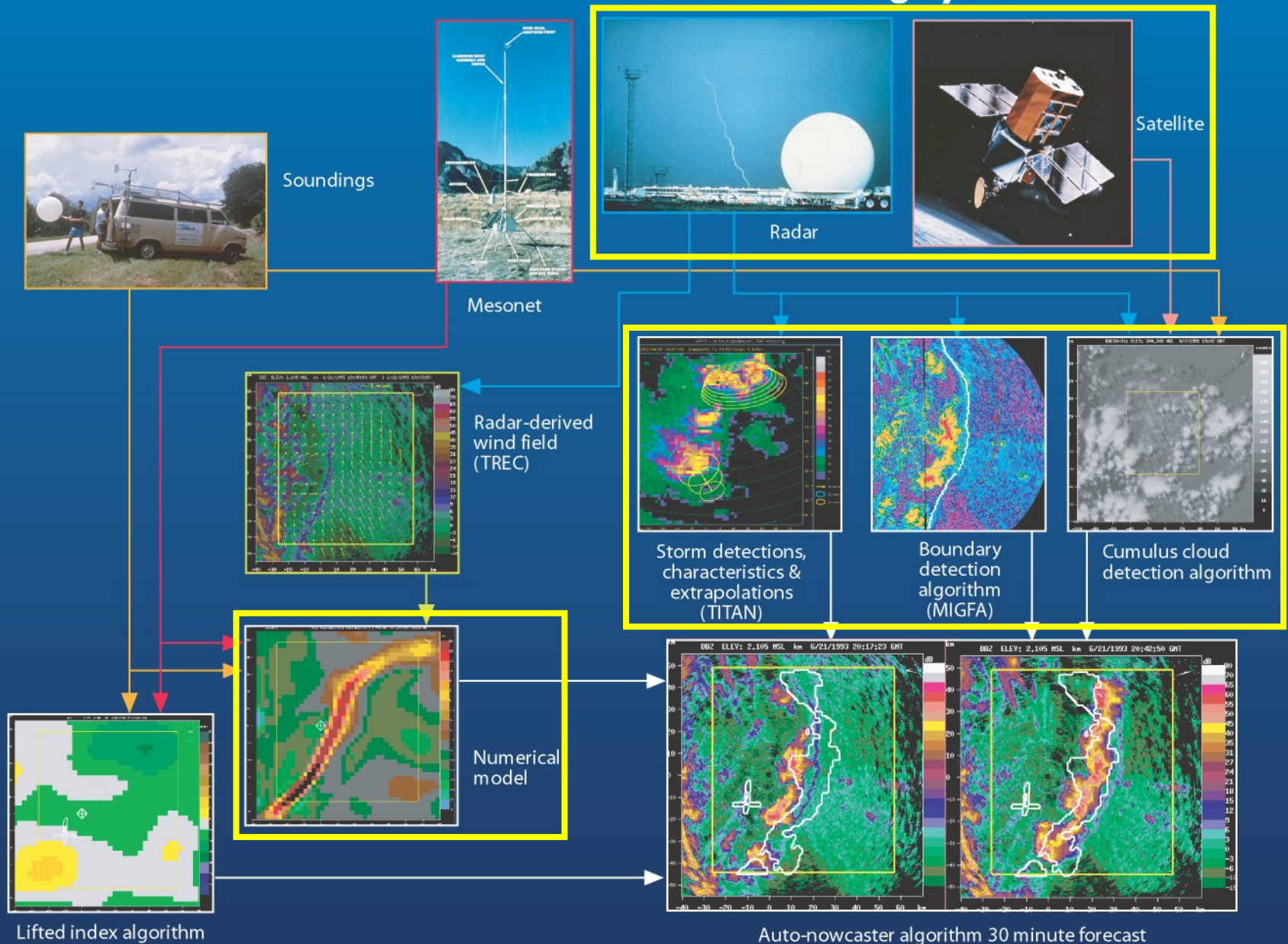
**Results by Dr.
Paul Harasti,
UCAR visiting
scientist at
NRL**

**Algorithm
provided by
Dr. John
Gamache**



National Center for Atmospheric Research

The Thunderstorm Auto-Nowcasting System



Cathy Kessinger et al., NCAR

Thunderstorm Nowcasting in an Oceanic Environment

9-10 September 1999

- An eastward-moving squall line off the coast of Florida, dissipating and separating into northern and southern branches
- USS O'Kane was ~75 km east of the Jacksonville, FL NEXRAD
- 21 volumes of SPY-1/TEP data collected from 2350 to 0253Z every 3-15 minutes
- GOES IR data and Rapid Update Cycle (RUC) model data used
- SPY-1/TEP reflectivity data were thresholded at 3 dBZ to preserve unclassified status; therefore, human-drawn reflectivity thin lines define the location of boundary layer convergence zones used by AutoNowcaster to define regions of uplift suitable for convective development
- 3 runs of AutoNowcaster to test effects of data availability and human-inserted convergent boundary on the quality of 30 min. thunderstorm forecasts

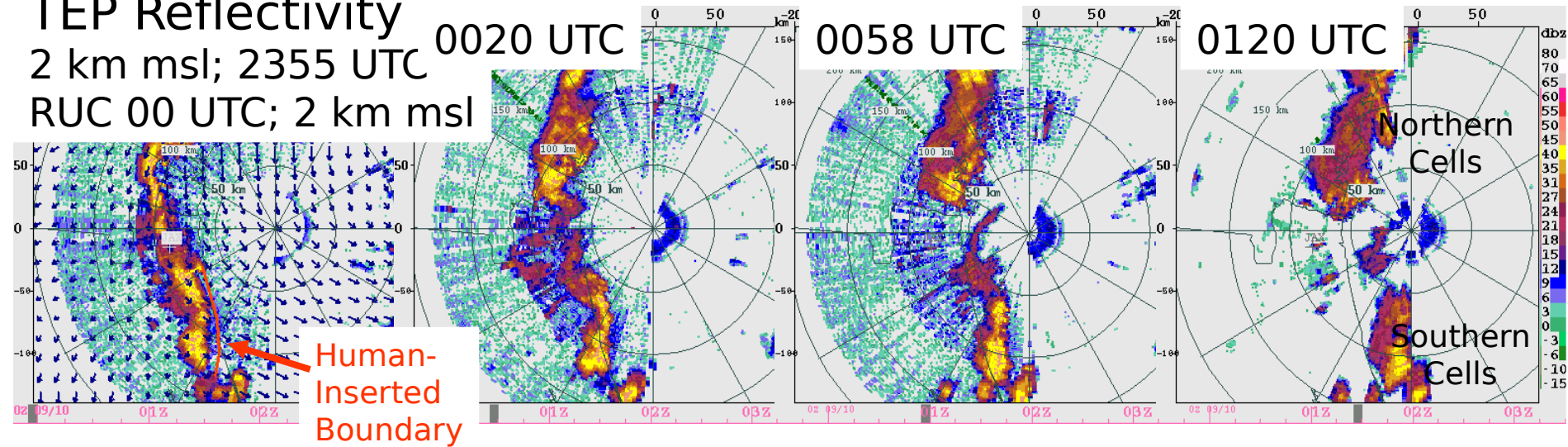
Run 1: Radar and satellite data sets; RUC winds and soundings; no human-inserted boundaries

Run 2: Radar data set; RUC winds and soundings; human-inserted boundaries

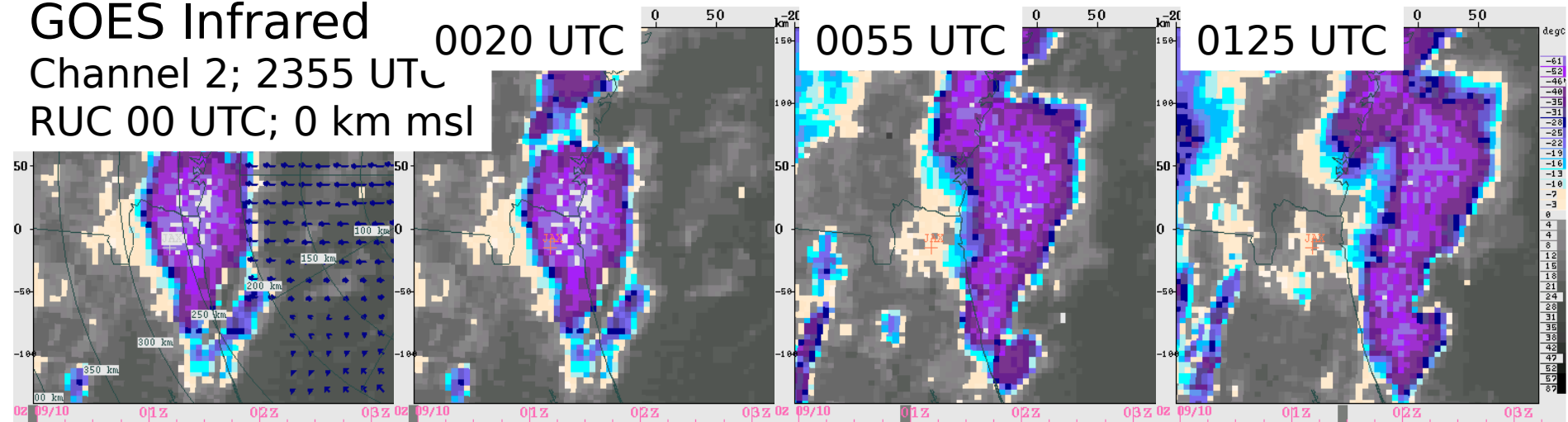
Run 3: Radar and satellite data sets; RUC winds and soundings; human-inserted boundaries

Thunderstorm Nowcasting in an Oceanic Environment

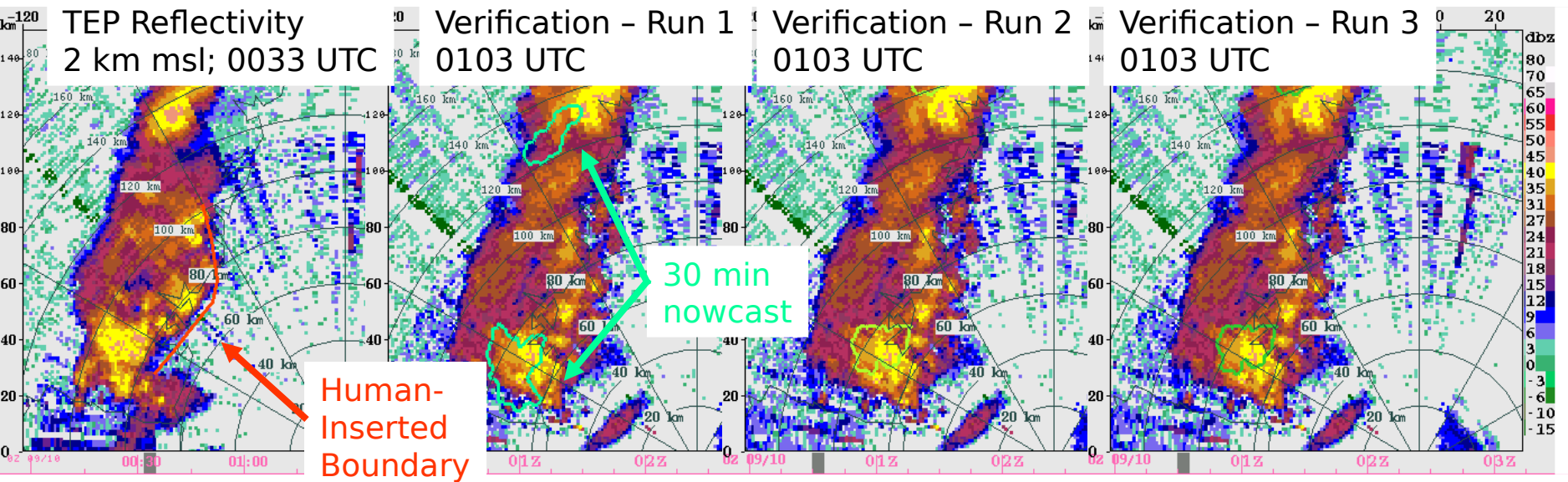
TEP Reflectivity
2 km msl; 2355 UTC
RUC 00 UTC; 2 km msl



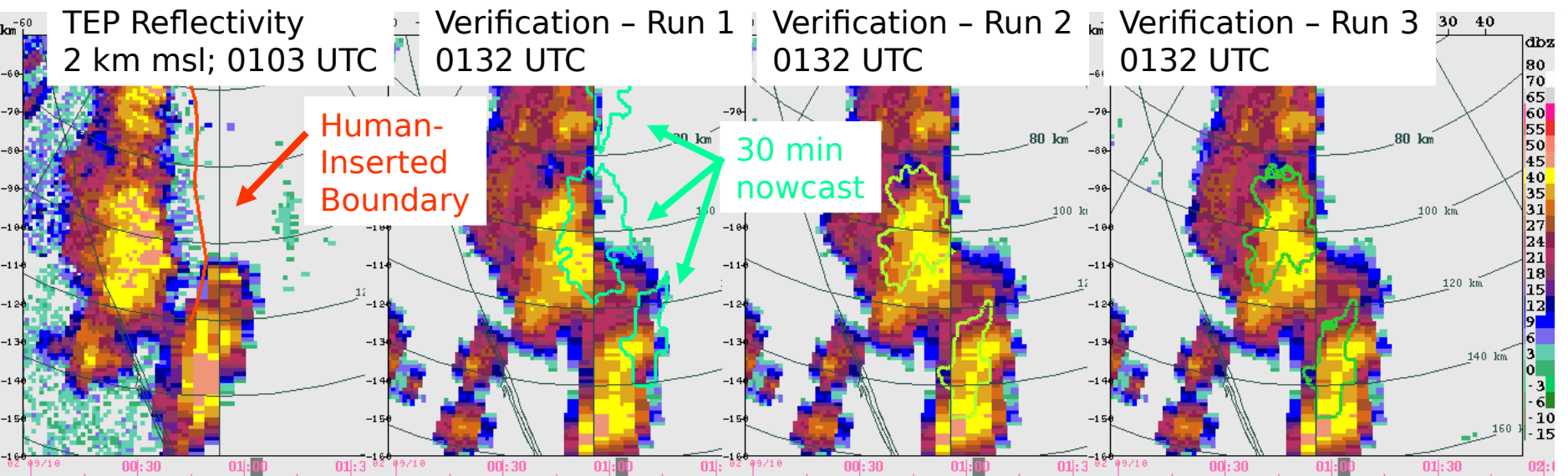
GOES Infrared
Channel 2; 2355 UTC
RUC 00 UTC; 0 km msl



Northern Cells - 30 minute nowcasts for all



Southern Cells - 30 minute nowcasts for all





Thunderstorm Nowcasting in an Oceanic Environment

The US Navy and Marine Corps Corporate Laboratory

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Results

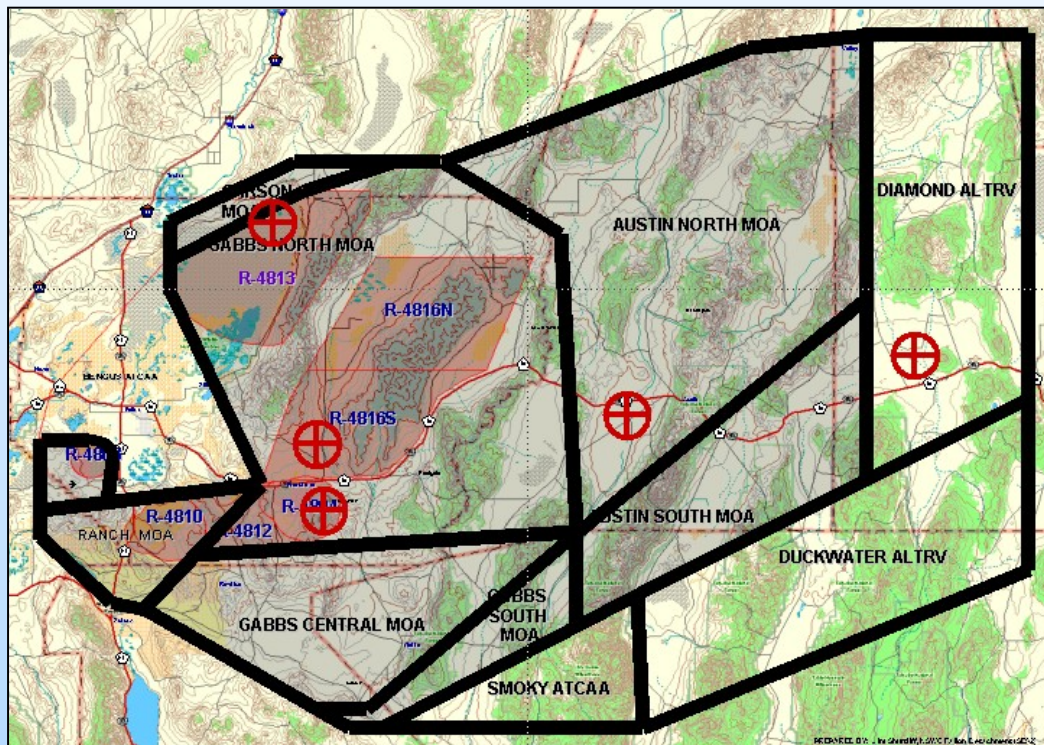
- Run 1 produces nowcasts with the least accuracy due to the absence of the human-inserted boundaries
- Runs 2 and 3 are nearly identical in quality; their input differs only by the use of satellite imagery
- Comparing Run 1 to Runs 2 and 3 illustrates the importance of the boundary layer convergence zones in producing high quality nowcasts
- Because this squall line is at mature/dissipating stages of evolution with large regions of anvil cloud present, the satellite imagery contributes little to the nowcast and explains the similarity between Runs 2 and 3; the AutoNowcaster uses satellite imagery to define regions of cumulus cloud development



NSAWC as a NOWCAST Test Site

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The US Navy and Marine Corps Corporate Laboratory



- Complex terrain and complex wind flow
- Thunderstorms and microbursts
- Winter storms
- Ceiling and visibility restrictions
- Icing conditions
- Blowing dust
- Weather on target

- We need to be where the warfighter trains
- Enhance dedicated METOC support for STW with R&D partnership between NRL, NPMOD Fallon and NPMOC-SD
- Work with NSAWC to “fine-tune” NOWCAST development
- Introduce warfighters to advanced R&D capabilities while collecting warfighter feedback
- Entrain additional system concepts
 - Interact with STW Commander’s Watch Station (A/B Papa cell)
 - Weather in the cockpit
 - Interface JMPS, REDS, IRTSS, etc.
 - Target Area METOC (TAM) and target area UAV data
 - Surface verification network





Issues

- **Verification and Validation**
- **Automated Quality Control**
- **Model Representation of Terrain**
- **WGS-84 Compliance**
- **GIS Interface**
- **Communications**
- **Optimal Manning**



Summary

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- NOWCAST and COAMPS-OS™ fit into existing capabilities and transformation concepts
 - FORCEnet / TFW / NFN
 - 4D Cube / VNE
 - NITES / TEDS / COAMPS-OS
 - REA
- NOWCAST fuses “thru-the-sensor” and other data together to provide a new capability
- NOWCAST is the Navy’s unique capability to provide “weather right now” to serve the warfighter’s needs in the Battlegroup
- Through NSAWC, we do not have to wait until all components of the “thru-the-sensor” suite are in place at sea to evolve the concept with the strike warfighter



NOWCAST

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The US Navy and Marine Corps Corporate Laboratory



News FAQ IPT Forum DEMO Downloads Tech Support

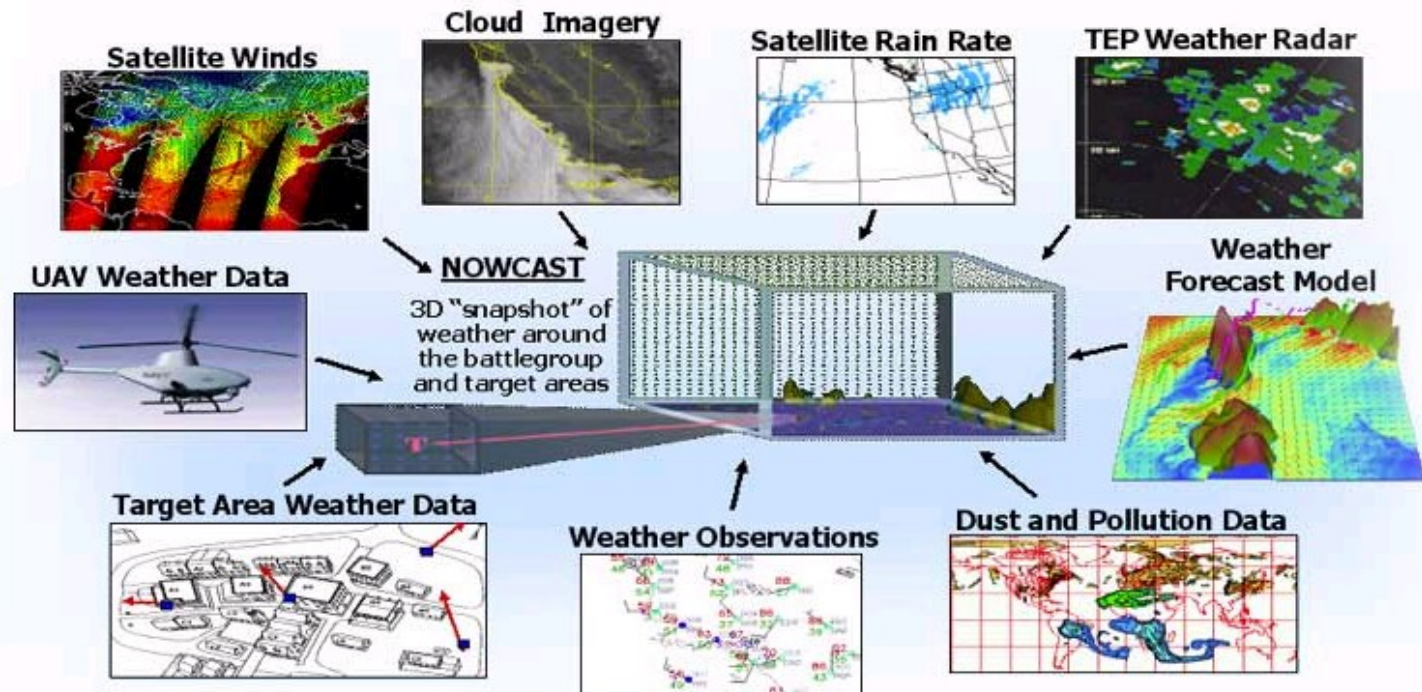
FOR THE NEXT GENERATION NAVY NOWCAST

NRL Home
Visit Request
Contact Us
Submit Feedback

NRL Monterey Marine
Meteorology Division
(Code 7500)

This is a U.S.
Government Computing
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disclaimer before
proceeding:
[Security Banner](#)

Approved for public
release by:
[Dr. Merilees](#),
Superintendent



<http://www.nrlmry.navy.mil/Apps/nowcast>





METOC Parameters Impact Decision Making

The US Navy and Marine Corps Corporate Laboratory

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Decision Optimization

Capability

Will I be able to engage the target?

How do I optimize my weapons load-out?

Can I conduct BDA/BHA?

Ceiling, Visibility,
Dust/Haze/Smoke, BIC, Cloud
Cover, Winds, Absolute Humidity
in the Target Area

What is the chem/bio dispersion
pattern?

Winds and Sea State within the
Battlegroup

How do I optimize Naval Gun Fire
support?

Winds, Sea State, Ceiling,
Visibility and Hazardous
Weather around the Carrier

Where can we launch and recover?

Winds, Clouds, Icing and
Turbulence Enroute



NOWCAST Phased Technology Plan

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What's available now with R&D NOWCAST:

- **Geostationary satellite data from Terascan system (FMQ-17)**
- **CONUS NEXRAD reflectivity data from NRL (or FNMOC)**
- **Quality controlled global observations and model grids from TEDS**
- **Horizontal visibility, cloud ceiling, and flight category from NCAR C&V**
- **Cloud base, top, and location from ADAS, including confidence level**
- **Composite NEXRAD radar combined with satellite for hazardous weather animations**
- **Dynamic station data plots and information**
- **Global relocatability, zooming, navigation, with dynamic map serving**
- **User authentication, interactive product selection and folders, unit conversion**
- **Derived products stored in TEDS for VNE and for use by other applications, TDAs**

What additionally will be available by the end of FY03:

- **Single Station Radar Reflectivity, Radial Wind, Echo Tops, Precipitation Rate, and VAD Wind Profile Animations**
- **NEXRAD composite Radar Echo Tops and Precipitation Rate animations**
- **High resolution 3D winds from 3.5DVAR and NOAA multiple Doppler algorithms using Level II NEXRAD data**





NOWCAST Phased Technology Plan (con't)

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FY04 Plans:

- **Develop TEP, SWR, and SPS-48 interface and QC for local radar data**
- **Develop multiple Doppler winds algorithms**
- **Create time series and cross section applications**
- **Improve C&V algorithm**
- **Develop convective storm tracking and motion algorithm**
- **Develop products for electromagnetic duct height and propagation conditions**
- **Enhance verification and product confidence level algorithms**
- **Improve administration user interface**

Future Plans (FY05-06):

- **Develop thunderstorm initiation and dissipation algorithm**
- **Develop wind shear and microburst alerts**
- **Develop algorithms for extent of in-flight icing and turbulence**
- **Create three-dimensional depictions of hazardous areas**
- **Implement GIS interface**





Local Environmental Characterization Requires a Telescoping Strategy

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- **Global coverage**
- **Meso- to synoptic scale**
- **1-5d guidance (10d ensemble)**

COAMPS™ / "COAAMPS"

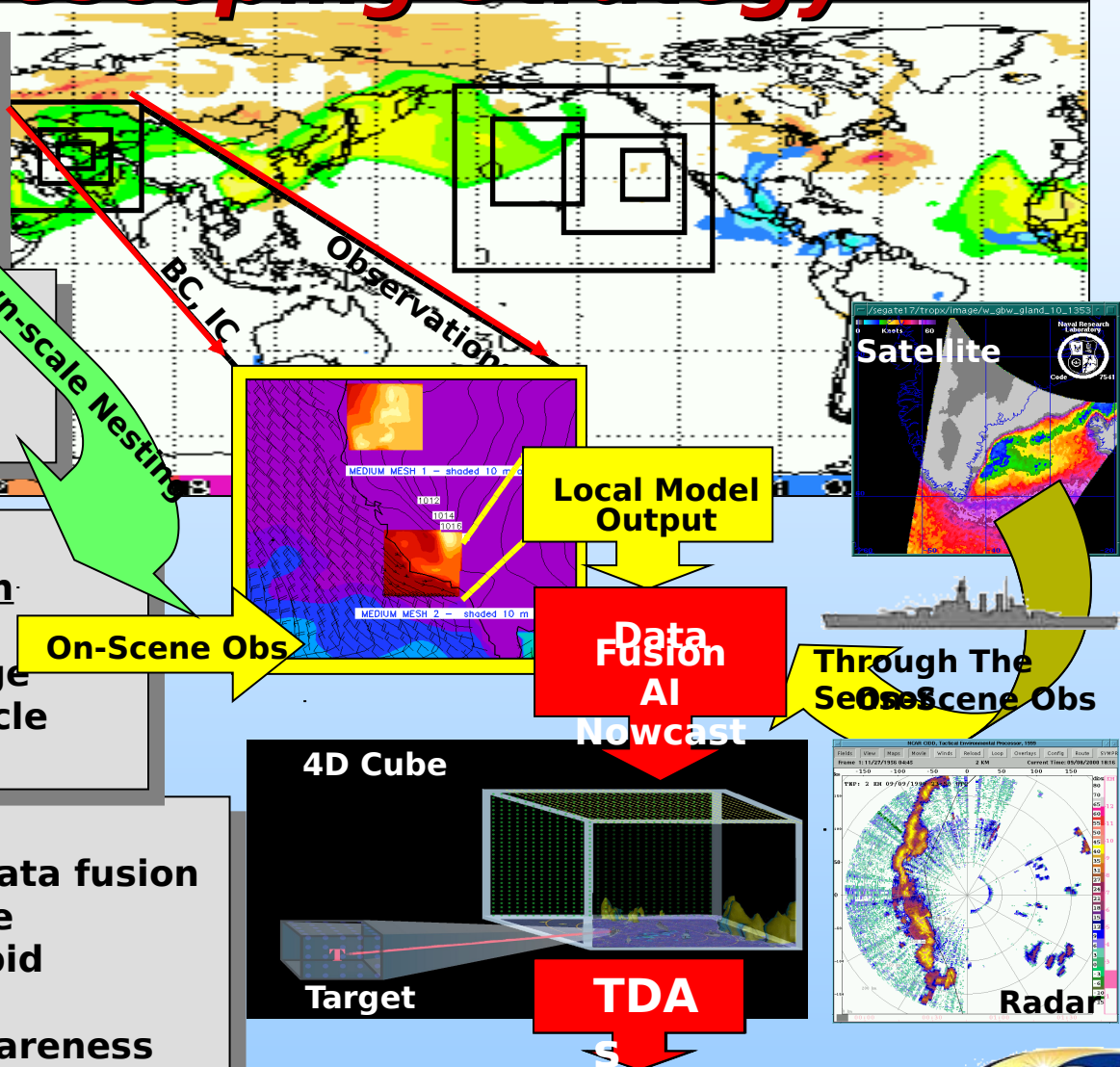
- **Nested regional coverage**
- **Nonhydrostatic scale**
- **0-72h forecaster guidance**

COAMPS-OS™

- **On-scene Data Assimilation system**
- **Tactical scale/local coverage**
- **1-12h data assimilation cycle**
- **Anytime, anywhere**

NOWCAST

- **Real-time, automatic, data fusion**
- **Warfighter time & space requirements (0-6h, rapid update)**
- **Common situational awareness**





COAMPS-OS™



The US Navy and Marine Corps Corporate Laboratory

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✓ Apr 2002 - V1.0

- Supports SGI, Sun; Web GUI; Single TEDS
- Delivered as two DII/COE segments to

✓ SPAWAR

Oct 2002 - V1.1

- COAMPS 3.0 (MPI); "On the fly" web graphics
- Delivered to FNMOC for DAMPS

May 2003 - V1.2

- LINUX Cluster; ADAS and FMQ-17 interface

Oct 2003 - V1.3

- NAVDAS; Interactive meteograms

Apr 2004 - V1.4

- NOWCAST interface; 3.5DVAR with radar data

Oct 2004 - V1.5

- JEM, GIS and GFE interfaces; Dynamic moving nests

Apr 2005 - V2.0

- Integrated COAMPS-OS and NOWCAST

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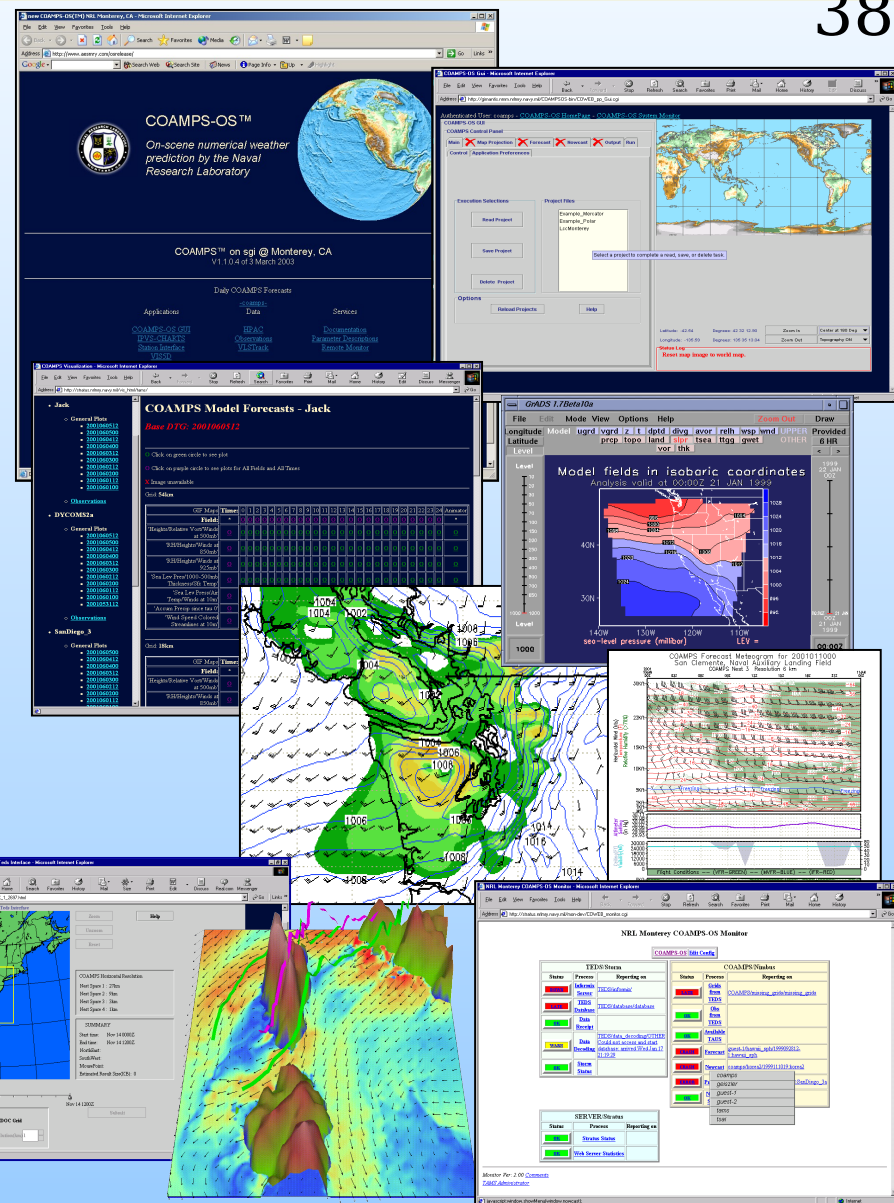
COAMPS-OS™ Web-Based Products



The US Navy and Marine Corps Corporate Laboratory

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- Multiple nests, hourly gridded forecast fields
 - IEEE, GRIB, NetCDF formats
 - Height and pressure surfaces; sigma levels
 - Web-based interface
 - TEDS database ready
- Web-based automated forecast weather map product matrix
 - Nested, single maps and animations
 - Web-based custom map interface
 - Forecast soundings, meteograms (weather forecast & aviation), and datagrams
- Web-based Application Suite
 - HPAC/VLSTRACK Interface
 - Station Interface
 - Observation Data Interface

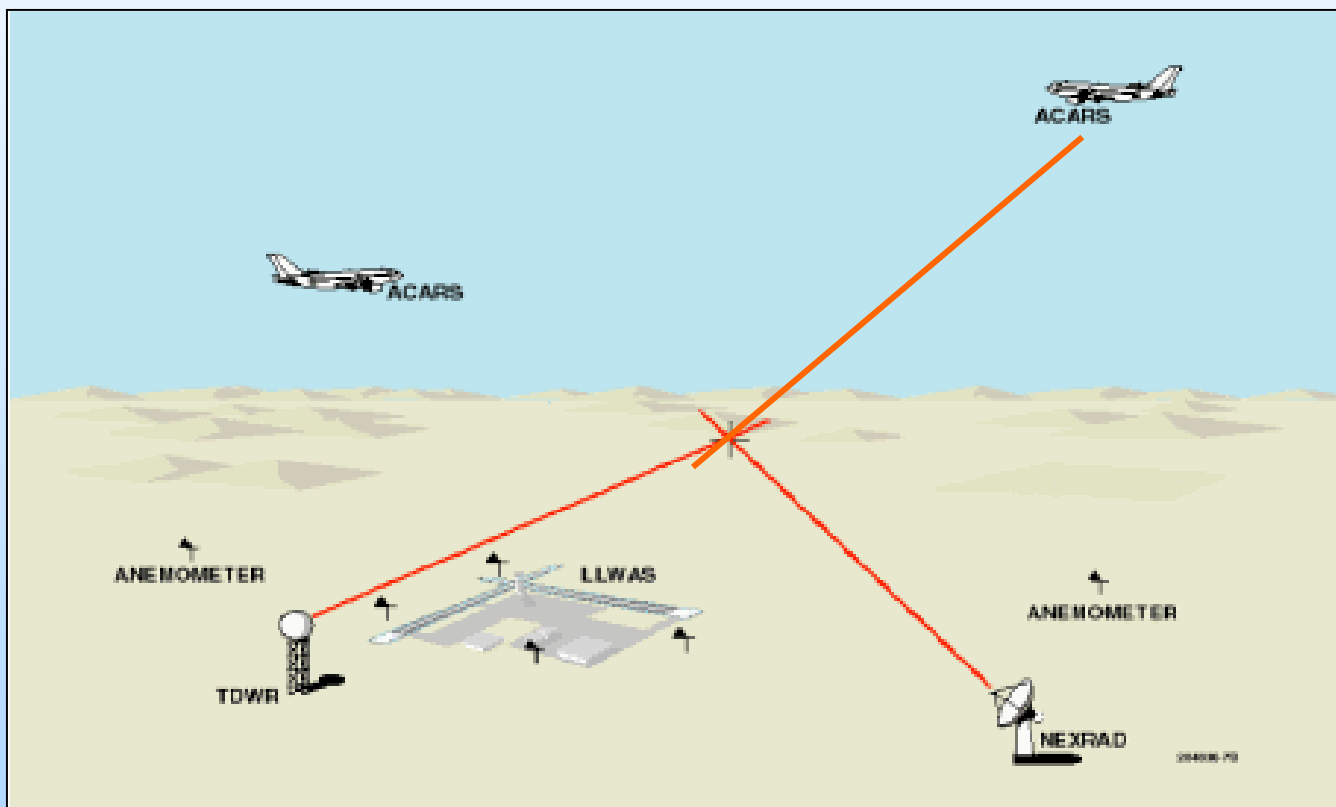




NOAA Multiple Doppler Variational Wind Analysis

The US Navy and Marine Corps Corporate Laboratory

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- Data format converted to UF
- Edit using QC software to remove noise, unfold radial velocities, etc.
- Interpolate to a common Cartesian grid
- Data from the multiple radars processed to generate a dual Doppler wind field
- Continuity equation used to deduce the vertical velocity